HAM TIPS
A PUBLICATION OF THE RCA TUBE DIVISION
Vol. XVII, No. 1 February, 1957

AUTOMATIC CONELRAD ALARM

Provides Constant Guard for Conelrad 'Alert'

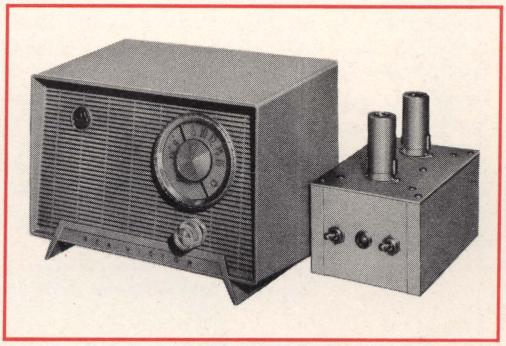
by G. D. Hanchett, W2YM
RCA Tube Division, Harrison, N. J.

The recent rulings by the Federal Communications Commission on Conelrad provide an excellent opportunity for amateurs who are interested in practical gadgetry. The writer, being one of those practical gadgeteers, and desiring to comply with the recent FCC ruling, constructed the automatic Conelrad alarm unit described in this article. This alarm unit can be used with any of the popularly-priced, five-tube, ac-dc broadcast receivers. Only one minor modification of the receiver is required, and this modification in no way affects its utility as a home receiver.

This Conelrad alarm unit does not require the use of relays. In addition, it emits a sound which is distinctive—there can be no mistake when the Conelrad "Radio Alert" is in effect.

The alarm unit consists of an oscillator of approximately 400 cps, which is keyed by a multivibrator at about 1 pulse per second. The multivibrator is controlled by a dc amplifier operated by the automatic-volume-control voltage of the broadcast receiver. Heater power is obtained from a miniature 6.3-volt, 1.0-ampere transformer. The "B" voltage (120 volts minimum, 250 volts maximum) is borrowed from the receiver.

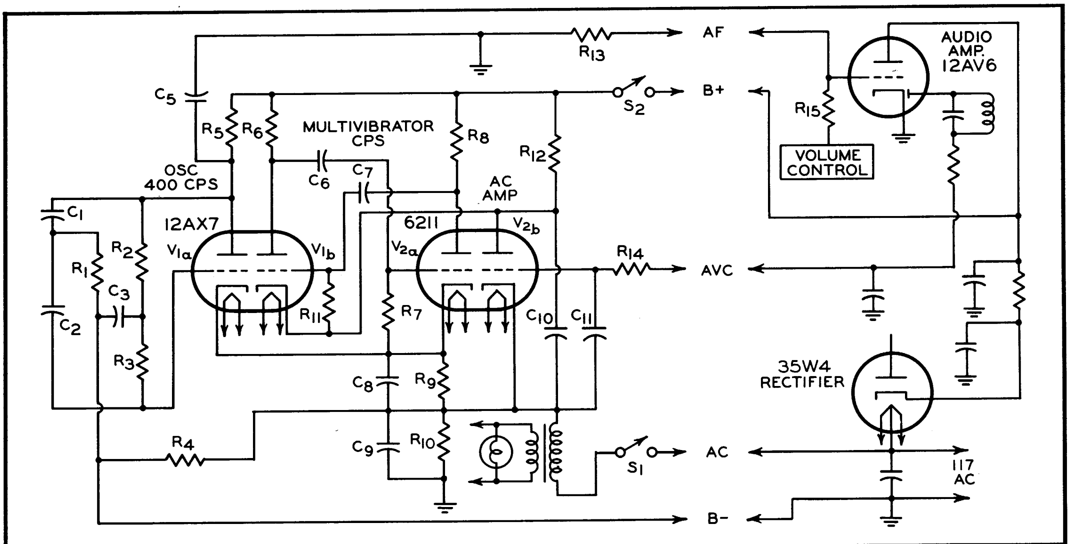
When the receiver is tuned to a broadcast station which provides 4 volts or more of avc voltage, the multivibrator triode section (V_{1b}) in series with the dc amplifier is held non-conducting. The second triode section (V_{2a}) of the multivibrator, consequently conducts continuously. Because the cathode resistor of the second triode of the multivibrator is in common with the cathode of the audio oscillator triode section (V_{1a}), the voltage drop across the cathode resistor is sufficient to cut off the audio oscillator and no audio tone is generated.



The automatic Conelrad alarm unit shown with the RCA model 6X5 series broadcast receiver. All components, except those visible in this view, are mounted on the underside of the cover plate.

When the Conelrad "Alert" is in effect, or when the broadcast station's carrier leaves the air and there is no avc voltage, the dc amplifier starts to conduct and sets the multivibrator into oscillation.

The multivibrator RC constants were picked so that it will oscillate at approximately one cycle per second. Therefore, the audio oscillator is keyed "on" and "off" at this rate. The output of the oscillator is connected to the control grid of the audio amplifier of the receiver and a series of "beeps" is emitted.



Parts list:
C_1—0.001 μf
C_2—0.001 μf
C_3—0.002 μf
C_4—0.01 μf
C_5—0.001 μf
C_6—0.25 μf
C_7—0.25 μf
C_8—0.25 μf
C_9—0.05 μf
C_{10}—0.1 μf
C_{11}—0.01 μf
L—indicator lamp, 6.3 volts, RCA-40

R_1—68,000 ohms
R_2—680,000 ohms
R_3—680,000 ohms
R_4—2.2 megohms
R_5—220,000 ohms
R_6—47,000 ohms
R_7—3.3 megohms
R_8—47,000 ohms
R_9—4,700 ohms
R_{10}—270,000 ohms
R_{11}—1 megohm
R_{12}—68,000 ohms

R_{13}—500,000 ohms
R_{14}—1 megohm
R_{15}—500,000 ohms
S_1—heater voltage switch
S_2—plate voltage switch
T—miniature transformer, 6.3 volts, 1.0 ampere
V_{1a}—, V_{1b}— RCA-12AX7 (½ audio oscillator, ½ multivibrator)
V_{2a}—, V_{2b}— RCA-6211 (½ multivibrator, ½ dc amplifier)

Schematic and parts list for automatic Conelrad unit.

Construction

Any broadcast receiver which will produce at least 4 volts avc can be used. The author used the popular RCA model 6X5C radio. This receiver is a 5-tube, ac-dc set which utilizes printed-wiring manufacturing techniques. Conversion is extremely simple.

The grid lead to the first audio amplifier, 12AV6, should be opened and a 500,000-ohm resistor (R_{15}) inserted, across which the audio output from the oscillator is impressed. This resistor permits the Conelrad alarm to operate regardless of the position of the volume control. Aside from this resistor and the external connections, no other alterations are required.

For convenience, an octal socket is placed in the center of the back of the receiver. This socket is used for connecting or disconnecting the Conelrad alarm unit without affecting normal operation of the receiver.

Wires from the ac, avc, B+, B— and grid of the first audio amplifier are connected to this socket. Shielded wires are, of course, used for all audio connections.

One triode section of a 12AX7 (V_{1a}) is used as the audio oscillator, while the other section of the 12AX7 (V_{1b}), together with one section of a 6211 (V_{2a}) is used as the multivibrator. The remaining section of the 6211 (V_{2b}) is used as the dc amplifier.

This tube arrangement was chosen because the audio oscillator needed a high-mu tube, and the dc amplifier needed a tube which has good control for cutoff characteristics. The 6211 was chosen because it is a twin triode especially designed for accurate "on-off" control of signals in applications such as electronic computers. Its grid cutoff characteristics are accurately controlled in manufacture. A 12AU7 could also be used in this socket, but the 6211 is designed to provide considerably superior performance in applications of this kind which may involve long periods of operation under cutoff conditions.

The alarm unit is constructed on a piece of aluminum 4″x6″, and mounted on a 4″x6″x 3″ chassis. All tube parts and components are attached to the cover with the exception of the control switches and pilot light.

The right-hand switch (S_1) turns on the heaters of the alarm unit, while the left-hand switch (S_2) controls the plate voltage. The heater switch enables the operator to activate the Conelrad alarm unit whenever he desires. The plate voltage switch is provided to eliminate the annoyance of an audible alarm signal as the receiver is tuned between stations. This feature is especially useful when it is desirable to have the alarm ready for instant use after tuning in a different station.

Since nearly all plastic-case, ac-dc sets have "hot-chassis" construction, a 0.05 μf capacitor (C_5) and a 270,000-ohm resistor (R_{10}) are connected between the B— and the metal chassis to eliminate the possibility of shock. If a transformer-type radio receiver is used, these components can be omitted and the B— can be connected directly to the metal chassis.

The components (R_1, R_2, R_3, R_4, C_1, C_2, and C_3) of the "T bridge" audio oscillator were selected to produce a frequency of approximately 400 cycles. Other frequencies can be obtained by increasing or decreasing the values of the resistors or the capacitors. Increasing the values of both types of components or decreasing these values, respectively decreases or increases the frequency.

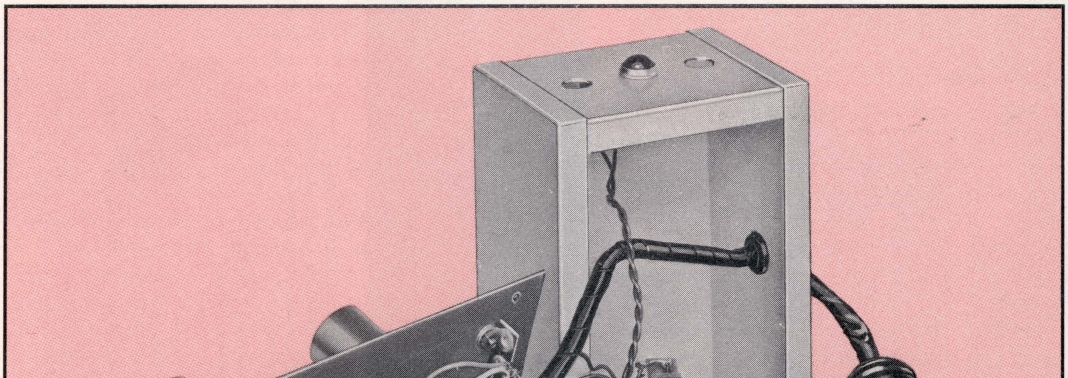
The rate at which these 400-cycle "beeps" will be produced is controlled by the time constant of the multivibrator (R_{11} C_7 and R_7 C_6). Again, increasing or decreasing the RC time constant will, respectively, decrease or increase the repetition rate.

A 68,000-ohm resistor (R_{12}) across that section of the 12AX7 used as a multivibrator insures that leakage currents from the 6211 will not start the system in operation.

This all-electronic, automatic Conelrad alarm unit fully satisfies the recent ruling (Docket 11488) of the Federal Communications Commission. It is simple, inexpensive, and easy to construct.

New Mike Box

The "make-your-own microphone" article by G. D. Hanchett, appearing in the September, 1956, issue of HAM TIPS (Vol. XVI, No. 3) described the construction of an aluminum box for housing the microphone. Bud Radio, Inc., manufactures a box which is ideally suited to the requirements of the transistorized microphone. Measuring 4" x 2¼" x 2¼", the box is available in gray (CU-2103) or etched (CU-3003) finish. Using this box, the base response of the microphone will be slightly higher than that described in the original article.



Placement of components under the cover plate. Note position of transformer. Resistors and capacitors are mounted on three terminal strips as shown.

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Harvey Slovik, Editor
Robert Leedy, Technical Editor

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HAM TIPS

A PUBLICATION OF THE RCA TUBE DIVISION

Vol. XVII, No. 2 April, 1957

RCA PUBLICATIONS FOR HAMS

New Transmitting Tube Manual Now Available

More and more hams are expressing unprecedented interest in the new 256-page RCA Transmitting Tubes (TT-4) manual. The new manual offers comprehensive and authoritative technical descriptions of 108 types of power tubes having plate-input ratings up to 4 kilowatts and 13 types of associated rectifier tubes. Maximum ratings, operating values, characteristic curves, outline drawings, and socket connection diagrams are also featured.

Covering basic theory of power tubes and their applications and written in an easy-to-understand style, the TT-4 manual contains information on generic tube types; tube parts and materials; tube installation and application; rectifier circuits and filters; interpretation of tube data; and the step-by-step design of af power amplifiers and modulators, rf power amplifiers, frequency multipliers, and oscillators. Simple calculations are given for determining operating conditions for class C telegraphy service, plate-modulated class C telephony service, frequency multipliers, and class AB and class B af amplifiers.

Rapid selection of an RCA power tube or rectifier tube for a specific application is facilitated by references to a series of five classification charts.

The TT-4 manual contains 16 circuit diagrams showing the use of RCA tubes. These circuits include a VFO for 3.5-4.0 Mc; crystal oscillators for both fundamental and harmonic output; amplifiers for class C telegraphy service and for class C plate-modulated service; modulators; an electronic bias supply; transmitters for operation at 2 meters, 10 meters, and 462 Mc; and others.

The manual, RCA Transmitting Tubes (TT-4), can be obtained from your local RCA tube distributor, or by sending $1.00 to Commercial Engineering, RCA, 415 S. 5th St., Harrison, N. J.

* * *

The capsule descriptions below point up the features of other technical manuals which radio amateurs are finding particularly useful in their hobby. Copies of these publications also can be obtained from your local RCA tube distributor, or directly from RCA Commercial Engineering.

* * *

RCA Receiving Tube manual (RC-18) is an up-to-date, 352-page book containing technical data on more than 575 receiving tubes. The book covers electron tube theory and applications, and is written in an easy-to-understand style. Other sections of the book include information on generic tube types, interpretation of tube data, and electron-tube installation. The price of the RC-18 is 75¢.

* * *

RCA Receiving Tubes for AM, FM, and Television Broadcast booklet (1275-G) is a 28-page publication containing classification charts, characteristic charts, and base and envelope connection diagrams on more than 600 entertainment receiving tubes and picture tubes. Price: 25¢.

* * *

RCA Interchangeability Directory of Industrial-Type Electron Tubes (ID-1020A) is a 16-page booklet which lists more than 2,000 type designations from 26 different manu-

facturers, arranged in alphabetical-numerical sequence. The listing shows the RCA direct replacement tube type, or the similar tube type, when available. Price: 25¢.

Longer Life for Your 6146's and 866-A's

The RCA-6146 beam power tube and the RCA-866-A half-wave mercury-vapor rectifier tube continue to be increasingly popular among hams. A few do's (noted below) should help to considerably increase the already long life of these two types.

Do's for the 6146

- Hold heater voltage at 6.3 volts—at tube terminals.
- Provide for adequate ventilation around tube to prevent tube and circuit damage caused by overheating.
- Keep shiny shielding surfaces away from tube to prevent heat reflection back into tube.
- Design circuits around tube to use lowest possible value of resistance in grid circuit and screen circuit.
- In high frequency service, operate tube under load conditions such that maximum rated plate current flows at the plate voltage which will give maximum rated input.
- Have overload protection in plate and screen circuits to protect tube in the event of driver failure.
- See that plate shows no color when operated at full ratings (CCS or ICAS conditions).
- Reduce B+ or insert additional screen resistance when tuning under no-load conditions to prevent exceeding grid-No. 2 input rating.
- Maintain tuning and loading adjustments precisely so that tube will not be subjected to excessive overload. The 6146 is a high-gain, high-perveance tube and can be more easily overloaded through circuit misadjustments than older types not having such features.
- Use adequate grid drive, keeping within maximum grid-current and screen dissipation ratings of tube. Too little grid drive can cause high plate dissipation.
- Make connections to plate with flexible lead to prevent strain on cap seal.
- Operate 6146 within RCA ratings as shown in technical bulletin available on request from RCA Commercial Engineering, Harrison, N. J.

Do's for the 866-A

- Hold filament voltage at 2.5 volts—at tube terminals. (Safety note: Do not measure filament voltage with the high-voltage transformer turned "on.")
- Hold condensed-mercury temperature within minimum and maximum ratings (20° C to 80° C with maximum peak inverse anode voltage of 2.5 Kv; 20° C to 70° C with maximum peak inverse anode voltage of 5 Kv; 20° C to 60° C with maximum peak inverse anode voltage of 10 Kv). Condensed mercury temperature can be measured at the bottom of the glass envelope, close to the base, with a small thermometer attached to the glass with a minimum amount of putty. Recommended operational temperature: 40° ± 5° C.
- Heat filament fully before applying anode voltage (15 seconds under normal conditions).
- After transporting tube, do not apply anode voltage until mercury has been redistributed (by heating filament only for 30 minutes).
- After idle periods, raise anode voltage slowly to the normal operating value.
- Keep rf out of rectifier compartment.
- Operate tube within ratings as shown in the RCA Transmitting Tube Manual TT-4.

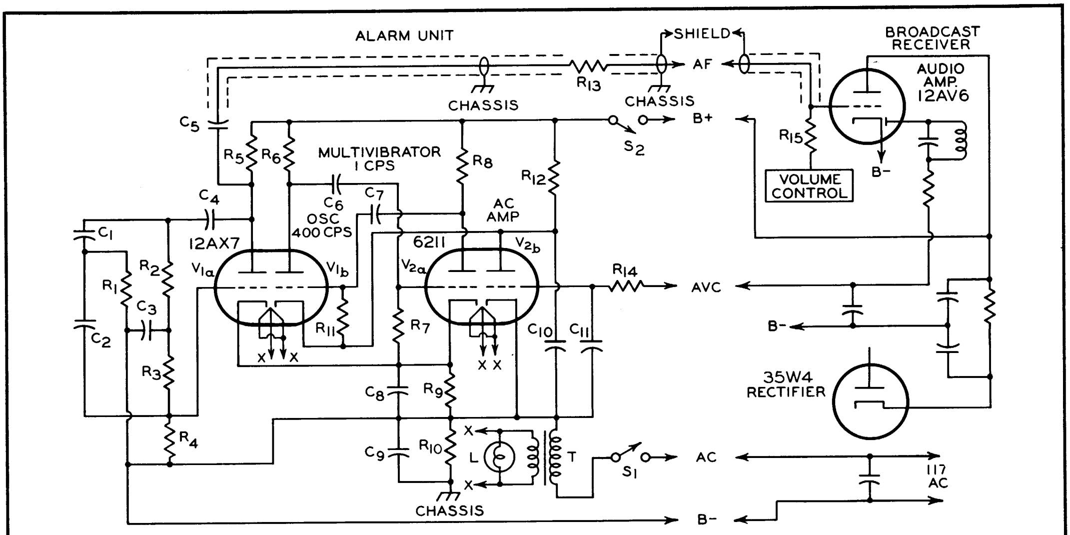
Back Issues of HAM TIPS Available

New amateur radio enthusiasts (we mean hams) and some of the oldtimers will be interested to learn that some of those recent back issues of HAM TIPS are still available. If you've missed any of the issues listed below, just drop a note to your technical editor, Bob Leedy, RCA HAM TIPS, 415 S. 5th St., Harrison, N. J., and we'll mail it with the compliments of your local RCA distributor.

Ham Band Charts (Vol. XVI, No. 1, March, 1956) was one of the most popular items ever to appear in this publication. This amateur-band frequency graph, showing useful data on the ham bands from 1.8 to 148 Mc, has been reprinted several times due to the many requests from hams.

Versatile Modulator (Vol. XVI, No. 2, July-August, 1956) by Peter Koustas, W2SGR, gave complete instructions for building a modulator providing any audio power between 25 and 100 watts and, therefore, can modulate 100% any rf input power up to 200 watts.

The Make-Your-Own Microphone (Vol. XVI, No. 3, September, 1956) by G. D. Hanchett, W2YM, describes a very popular transistorized microphone which has all the features desirable for mobile operation: good audio quality, fairly high signal output, insensitivity to unwanted electrical pickup, rugged construction and low price.



C1, C2, C5—0.001 μf
C3—0.002 μf
C4, C11—0.01 μf
C6, C7, C8—0.25 μf
C9—0.05 μf
C10—0.1 μf
L—indicator lamp, 6.3 volts, RCA-40
R1, R12—68,000 ohms
R2, R3—680,000 ohms
R4—2.2 megohms
R5—220,000 ohms
R6, R8—47,000 ohms
R7—3.3 megohms
R9—4,700 ohms
R10—270,000 ohms
R11, R14—1 megohm
R13, R15—500,000 ohms
S1—heater voltage switch
S2—plate voltage switch
T—miniature, transformer, 6.3 volts, 1.0 ampere
V1a } RCA-12AX7 (½ audio oscillator,
V1b } ½ multivibrator)
V2a } RCA-6211 (½ multivibrator,
V2b } ½ dc amplifier)

Schematic and parts list for automatic Conelrad unit.

Let's Face It!

Correction please: In the Automatic Conelrad Alarm article* which appeared in the February issue of HAM TIPS (Vol. XVII, No. 1), capacitor C_4 was included in the parts list, but was inadvertently omitted from the circuit schematic. The schematic should have shown the capacitor connected between the plate of V_{1a} and the junction of capacitor C_1 and resistor R_2. The corrected schematic is shown above.

The position of R_4 in the schematic was incorrect and has been changed as shown above. R_4 now connects to the grid of V_{1a} and to B—. The ground shown between C_5 and R_{13} on the af-output line is also in error. The output lead from C_5, through R_{13} and to the grid of the audio amplifier in the receiver, should be a shielded cable with the shield connected to the chassis of the alarm unit.

The 0.05-μf capacitor (C_9) and the 270,000-ohm resistor (R_{10}) should be shown connected between the B— and the metal chassis, not ground. In the text of the original article, capacitor C_9 was erroneously referred to as C_5. When a transformer-type radio receiver is used, C_9 and R_{10} can be omitted and the B— connected directly to the metal chassis.

Description: For the information of those readers who may not have acquired copies of the original article, the Conelrad Alarm unit can be used with any 5-tube ac-dc broadcast receiver producing at least 4 volts avc.

As shown in the diagram above, wires from the grid of the first audio amplifier, its shield, B+, avc, ac, and B— of the receiver are connected to the alarm unit. The "B" voltage can range from 120 volts minimum to 250 volts maximum. The author used the popular RCA model 6X5-series broadcast receiver and connected the Conelrad alarm unit to the receiver as shown in the right-hand portion of the schematic diagram. The only modification of the receiver required is the addition of a 500,000-ohm resistor (R_{15}) inserted between the grid lead of the receiver's first audio amplifier (12AV6) and the volume control.

When the Conelrad "alert" is in effect, or when the broadcast station's carrier leaves the air, the output of the alarm's audio oscillator will cause the receiver to emit a series of 400-cycle "beeps" at 1-second intervals.

*Automatic Conelrad Alarm by G. D. Hanchett, W2YM RCA Tube Division, Harrison, N. J.

Close-up view of the RCA-807 final amplifier in the S-255.

RCA-807 Beam Power Tube —world-famous in rf amplifier, frequency-multiplier, and modulator service.

The popular Allied Knight-Kit S-255 transmitter for 80, 40, 20, 15, and 11-10 meters.

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Compact, versatile, and capable of delivering a hefty CW signal on any band from 10 to 80, Allied's Knight-Kit S-255 transmitter pictured here is making friends with novices and seasoned amateurs alike for its outstanding on-the-air performance. The rig is designed around an RCA-807 beam power final!

And there's good reason why RCA-807 is specified in so many amateur and commercial designs. The tube has an excellent watts-per-dollar factor. Performance is noteworthy—even at low plate voltage. And, of course, an RCA-807 is easy to excite (a single 6AG7 can drive it to full plate input; a pair of 807's can modulate it).

RCA-807—as well as the complete line of RCA beam power tubes, triodes, and rectifier tubes—is available through your RCA Tube Distributor. For technical data on RCA-807 write RCA, Commercial Engineering, Section ——, Harrison, N.J.

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HAM TIPS

RCA

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Vol. XVII, No. 3 July, 1957

A TRANSISTORIZED QSO-GETTER

For 40-Meter QRP CW Operation

by E. M. Washburn, W2RG*

Many radio amateurs have expressed a keen interest in the amazing possibilities of low-power transistorized transmitters. This expressed interest has prompted the following description, so that others may join the growing ranks of QRP operators working hundreds—or even thousands—of miles on a fraction of one watt input.

The transistorized QRP transmitter illustrated and described in this article is essentially a 40-meter cw rig, using one RCA-2N140 transistor in the crystal oscillator and another in the amplifier. The transmitter is adequately powered by two 6-volt, heavy-duty dry batteries, connected in series, which are provided with a switch to permit tuning up at 6 volts. When the transmitter is operating at full load, the crystal oscillator operates at 12 volts with a collector current of 15 milliamperes, while the amplifier operates at 12 volts, 18 milliamperes. Admittedly, these inputs are *in excess* of the manufacturer's ratings and some transistors may not operate satisfactorily under these overload conditions. An RCA-VSO69 1.5-volt dry cell is used in the oscillator emitter circuit as shown in the schematic diagram.

During the Spring and Fall of 1956, the author worked 18 states, Ontario, Quebec, Puerto Rico, Windward Islands and Transvaal, S. Afr.—all on 40 meters—with an antenna consisting of a single, 106-foot wire. The wire used with the author's transmitter is strung 28 feet across the basement rafters, then leaves the confines of the shack and slopes upwards for a distance of 42 feet to a flat top which is 36 feet long and 28 feet above the ground. The antenna can be voltage-fed from the amplifier or it can be fed from the antenna tuner.

Over a long period of operations, the signal reports received by the author have varied from RST-339 to 589, depending upon band conditions, distance and the type of receiver used by the receiving station. The QSO with Transvaal, S. Afr., (ZS6TR) appears to be a world record for a 40-meter low power/transistor transmitter and the contact was made without any form of prearrangement and without any previous communications using a higher-power rig. At 216 milliwatts and covering a distance of 8,000 miles, this performance is comparable to 37,000 miles per watt at a frequency of 7002 Kc.

Several contacts have been made on the 80-meter band, but the most gratifying and successful results have been accomplished in the 40-meter band. To the present, no attempt has been made to put the QRP transmitter on the 20-meter or the higher frequency bands; however, this band could be worked by using the amplifier as a doubler stage and substituting an RCA-2N247 transistor for the RCA-2N140.

*Manager, Frequency Control Engineering, RCA, Camden, N. J.

Complete transistor rig. Maximum input to the final amplifier: 216 Mw.

CONSTRUCTION

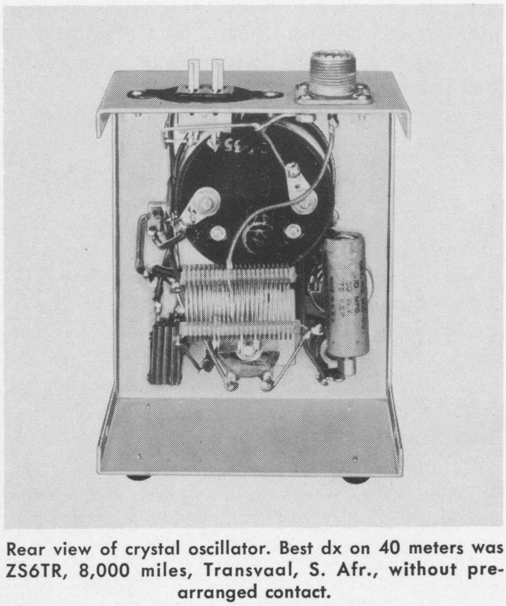
The complete transistor transmitter station comprises five units as shown in the photograph. The wave meter would normally be placed several feet away with its pickup coil about 2 inches from the antenna wire. Since this absorption wave meter is entirely conventional and the battery box is merely a housing for the two 6-volt dry batteries and the 1.5 volt dry cell, the circuit description will be limited to the crystal oscillator unit, amplifier and antenna tuner. Each of these three units is housed in a minibox which measures 5 inches by 4 inches by 3 inches. Interior construction details are shown in the photographs of each.

Although VFO circuits have been tried, the only successful operation has been with crystal control, and in this particular design the crystal unit is in the emitter circuit. The key is by-passed by a low-voltage 2 μf capacitor to improve keying characteristics, particularly when a "bug" is used. The most critical adjustment is the location of the output tap on the base inductor to achieve stable performance, free from "birdies."

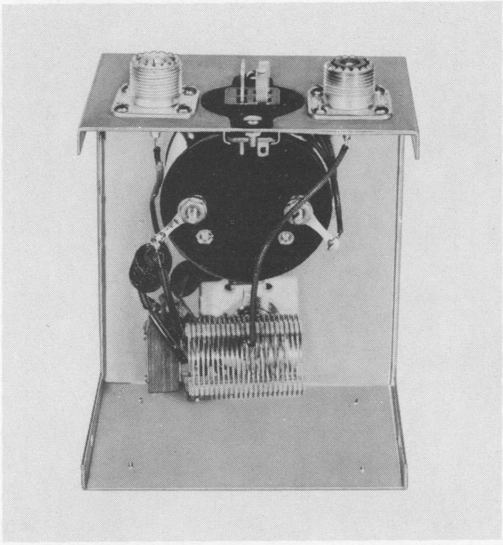
Whether or not an amplifier is used, the output tap on the tuned circuit inductor should be just far enough from the ground end for a stable signal, free from multivibrator type birdies when the key is first closed. In the unit described, the tap is almost at midpoint, 10½ turns from the ground end with a total of 23 turns in the coil. The optimum location for this tap must be obtained by "cut and try" method, keeping the collector voltage low and backing down on the emitter potentiometer to avoid exceeding 15 ma collector current.

The transistorized crystal oscillator is shown with the 2N140 transistor just above the crystal unit. The lower central knob adjusts the variable tuning capacitor, while the left-hand knob is used to set the "bias" potentiometer at optimum for clean keying at full output. The switch at the lower right is the main battery on-off switch, while the jack at the lower left is for the key. On top of the unit, the coax connector is for the rf output and the four-prong male connector is for the 12-volt and 1.5-volt supplies from the battery box. The inside components of the oscillator are shown in the photograph.

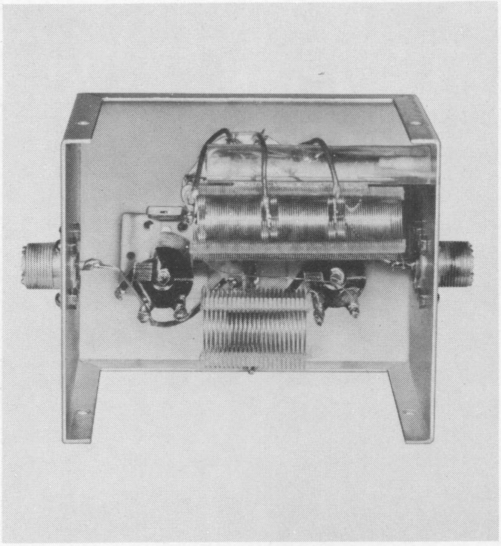
In the amplifier circuit, the only critical adjustment is the location of the tap on the



Rear view of crystal oscillator. Best dx on 40 meters was ZS6TR, 8,000 miles, Transvaal, S. Afr., without prearranged contact.

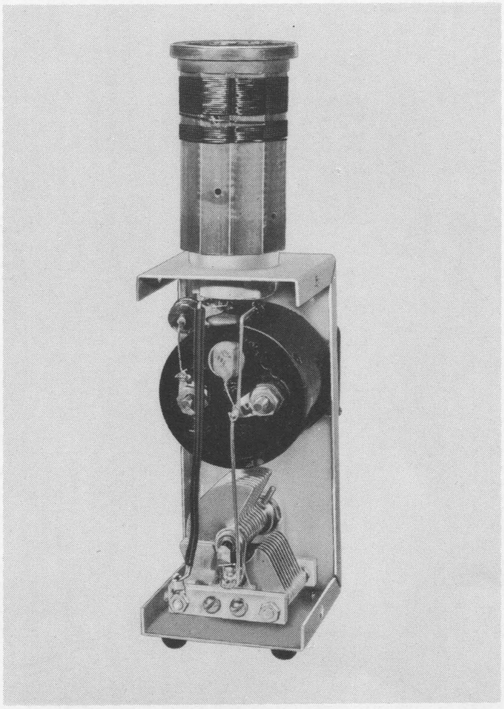


Rear view of transistor amplifier.



Interior view of antenna tuner.

collector tank coil. The optimum position must be found by trial, but should be near the midpoint or slightly towards the ground end. Because one set of batteries is used as the 12-volt supply for both the oscillator and amplifier, the on-off switch may be omitted since the common ground is made through the coax cable.



Construction details of absorption wave meter used to indicate maximum radiation from antenna.

The use of an antenna tuner was found helpful, although not essential. The absorption wave meter, however, is considered an absolute necessity, since it gives a sensitive indication of the radiated energy. During tuning operations, this meter pickup coil may be located close enough to the antenna wire (about 6 feet from the tuner or transmitter) to give a meter reading at about half-scale, assuming that full scale is about 200 μa. Then it should be removed completely or decoupled until the needle movement is just visible. Although the tuner circuit contains more components than absolutely required, it does permit precision tuning for optimum radiated power at minimum collector current, and in low power work of this particular type every individual milliwatt must be utilized to produce maximum power for maximum contacts.

As in conventional transmitter tuning, increasing the load will also increase the collector (plate) current, but instead of tuning the tank circuit for a dip in collector current, the more positive indication of proper loading is maximum wave meter current at minimum collector current. Maximum radiation normally will not be at maximum current in the collector circuit. Adjustment of the emitter potentiometer in the oscillator is quite critical for optimum setting.

In all tuning operations it is advisable to listen to the signal in the station receiver. As the voltage on the oscillator emitter is gradually increased and oscillation starts, the signal will sound very strong, even before there is

any indication of collector current in the amplifier. As the emitter potentiometer is advanced slowly, the oscillator collector current will increase and the keyed signal will become clean, with a slight ringing which is characteristic of crystal oscillator keying. Unfortunately, if there is any indication of radiated power under this setting of the potentiometer, it will be very small, and the emitter voltage should be further increased. At about 10 ma collector current, there should be a definite amplifier collector current and a wave meter indication of radiated power, and all tuning controls must be adjusted carefully until peak radiation is reached. During this final tuning, birdies are very liable to be heard in the receiver all over the dial, and tuning must be readjusted until the only signal heard is at the crystal frequency. If tuning alone is not effective in eliminating these spurious oscillations with a "cold" transistor, the emitter voltage in the oscillator must be reduced or the tap on its base coil moved further from the ground end.

When the keyed signal is clean and free from birdies, with collector current between 12 and 15 ma in the oscillator and 15 to 18 ma in the amplifier, and with a good indication of radiation in the absorption wave meter, that meter should be removed or coupled very loosely. The rig is then all set for normal use.

In at least one respect, however, operation will not be normal, and that is in establishing contacts. The only successful method experienced by the writer has been in answering general calls and rarely by calling CQ, CQ-TR, CQ-QRP, or any other form inviting a QSO. Experience teaches that it is well to listen for a few seconds before answering a CQ, to see if others are answering the same call. If so, it is almost a waste of time to answer, even assuming your crystal frequency is close enough to be hopeful of establishing contact. The writer has had best success by having a fair selection of crystals, choosing one which is in the least occupied portion of the band, tuning for optimum radiation at minimum power input, and waiting for someone to call CQ on that frequency. On 40 meters you don't have to wait long under normal conditions.

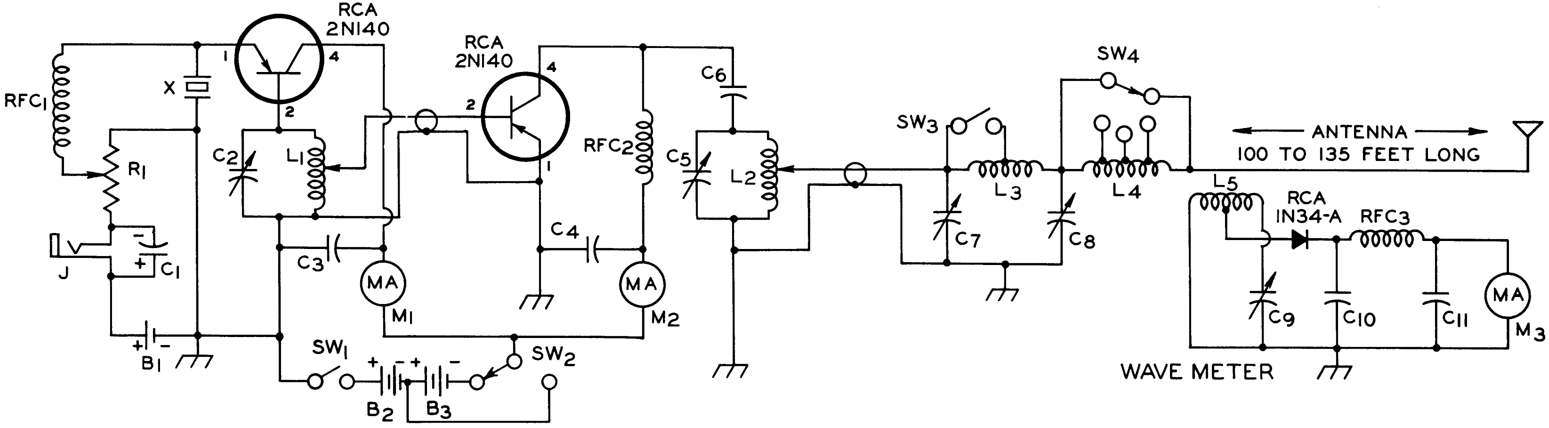
On 80 meters, a 2N139 may be used in place of the 2N140 and is slightly lower in price. Cutoff frequency of the 2N139 is approximately 5 Mc. The 2N140 should be used for 7 Mc operation, with its higher cutoff frequency at about 8 Mc. Future QRP rigs hold many possibilities of higher-frequency operation, voice modulation, and increased efficiency.

Your author wishes to emphasize the importance of selecting the proper location for the tap on the oscillator coil and also on the amplifier coil. Both are extremely critical *for optimum performance.* The antenna tuner described will load almost any kind of wire, but obviously the better antenna system employed, the better the results will be.

Your author has never used any form of beam and all contacts, nearly 200 at this writing, have been without previous arrangement and without previous contact with higher power equipment. In the author's opinion, such "piggy-back" contacts void the attraction of the adventure in transistorized QRP amateur communications.

PARTS LIST

B_1—Battery, 1.5-volt (RCA-VS069, or equivalent)
B_2—Battery, 6-volt (RCA-VS009, or equivalent)
B_3—Battery, 6-volt (RCA-VS009, or equivalent)
C_1—2 μf, electrolytic
C_2—0-100 $\mu\mu$f, variable
C_3—0.01 μf
C_4—0.01 μf
C_5—0-100 $\mu\mu$f, variable
C_6—0.001 μf
C_7—0-100 $\mu\mu$f, variable
C_8—0-100 $\mu\mu$f, variable
C_9—0-50 $\mu\mu$f, variable
C_{10}—0.001 μf
C_{11}—0.001 μf
L_1—23 turns B & W Miniductor #3015, tapped near center
L_2—23 turns B & W Miniductor #3015, tapped near center
L_3—23 turns B & W Miniductor #3015, tapped near center
L_4—2¾" length B & W Miniductor #3016, 3 equal taps
L_5—Any size 40-meter pickup coil center-tapped, which tunes through band, with C_9
M_1—0-20 dc milliameter
M_2—0-20 dc milliameter
M_3—0-100 microammeter
R_1—100,000 ohms
RFC_1—RF choke, 1 mh
RFC_2—RF choke, 1 mh
RFC_3—RF choke, 1 mh
SW_1—SPST switch
SW_2—SPDT switch
SW_3—SPST switch
SW_4—Switch, 4-position
X—Crystal, 3.5 or 7.0 Mc
RCA-2N140 Transistor (oscillator)
RCA-2N140 Transistor (amplifier)
RCA-1N34-A Semiconductor Diode (wave meter)



Grounds shown are to individual metal cases; no earth ground is used. Maximum collector input is 216 milliwatts to oscillator and also to amplifier. Batteries used should be heavy-duty dry cells.

40/80 METER TRANSISTOR TRANSMITTER

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From your local RCA distributor, headquarters for RCA receiving and power tubes.

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Harvey Slovik, Editor
Robert Leedy, W2PMP
Technical Editor

FORM 3547 REQUESTED

Again...

BEAM POWER TUBES PREDOMINATE!

Beam Power Tubes—an original RCA development—continue to hold top position among leading amateur and commercial equipment designers everywhere. Take the 1957 Radio Amateurs' Handbook. In this "official" amateur technical textbook, over 75% of all transmitter and modulator units described are built around beam power types.

Why is this so?

Because Beam Power Tubes fit transmitter requirements from every angle; they take less plate voltage—require fewer driver stages—make efficient bandswitching circuits practicable—deliver a whale of a signal at low overall transmitter tube cost.

So whether you are rebuilding or "re-tubing", RCA Beam Power Tubes are your best bet. They're available in amateur power ratings to meet your needs. Get them from your local RCA Tube Distributor.

TUBES FOR AMATEURS
RADIO CORPORATION OF AMERICA
Electron Tube Division   Harrison, New Jersey

HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. XVII No. 4 DECEMBER, 1957

HAM SHACK TROUBLE-SHOOTER

Solve Your Operations Problems with the Versatile RCA VoltOhmyst

By Rhys Samuel, W2GOQ

RCA Electron Tube Division, Harrison, N. J.

This feature is Part I of a two-part article covering the use of vacuum-tube voltmeters in the ham shack. Hams everywhere are finding the VTVM an indispensable tool because of the variety and wide range of measurements which can be made with these versatile and accurate instruments.

To the amateur who has used an RCA *VoltOhmyst®* for routine checking and trouble-shooting in his ham shack, the vacuum-tube voltmeter has become the first rival of the soldering iron.

VoltOhmysts* are useful in dozens of trouble-shooting applications in receivers, frequency meters, variable-frequency and crystal oscillators, exciter units, power amplifiers, power supplies of all sizes, and speech amplifiers and modulators. Factory construction and calibration on all functions and ranges against precise laboratory standards make the VoltOhmysts exceptionally dependable.

These instruments have an input resistance of 11 megohms on all dc-voltage ranges, making possible precise voltage measurements in power supplies which have limited current-drain characteristics.

VoltOhmysts are versatile measuring devices. The RCA WV-98A Senior VoltOhmyst, for example, can measure—in seven ranges—dc voltages up to 1500 volts, ac voltages up to 1500 volts rms (4200 v p-p), and resistance values up to 1000 megohms. When used with the WG-289 high-voltage probe, RCA VoltOhmysts can measure dc voltages up to 50 Kv. When the accessory WG-301A crystal-diode probe is used, rf measurements can be made up to 250 Mc. Because these instruments read resistance values up to 1000 megohms, they are invaluable in checking equipment for leaky capacitors and other high-resistance shorts which might not be detected with ordinary low-range ohmmeters.

Voltage Measurements

Before making any voltage measurements, always connect the ground cable of the VoltOhmyst to the equipment ground point. Greatest accuracy will be obtained when the scale which gives a reading nearest the full-scale point is used.

All of the VoltOhmysts are equipped with a single switch-type probe and cable for measuring both ac and dc voltages and resistances. For dc-voltage measurements, set the switch to "DC." It is now possible to make dc-voltage measurements in circuits which also contain an ac signal. This feature is valuable when trouble-shooting receivers and low-power exciter stages.

Set the switch to the "AC/Ohms" position for ac-voltage and resistance measurements.

*"VoltOhmyst" is a registered trademark of the Radio Corporation of America.

Resistance Measurements

The first rule to observe in making resistance measurements is to *remove all power from the circuit being tested.* Failure to observe this precaution may result in damage to the test instrument. It is also advisable to discharge all capacitors in the circuit under test to prevent their residual charge from adversely affecting the meter reading. The accuracy of the resistance measurement can be increased by using the scale which provides a reading nearest the centerscale point on the meter.

In a complex electronic circuit, shunt-circuit resistance may be difficult to determine. In such cases, it will be necessary to unsolder individual components or to disconnect major leads or buses before resistance measurements are made.

Measurements in RF Fields

Strong rf fields in transmitters may affect the meter measurement of either ac or dc voltages. In making such measurements in the presence of rf, always connect the VoltOhmyst ground cable to a point near the test point. If an auxiliary rf probe is used, ground the short lead on the probe as near as possible to the test point. If the rf field still upsets the meter reading, move the instrument to another position and re-orient the test leads.

The WG-301A crystal-diode probe (see inset of Figure 1) is a slip-on type which attaches to the front end of the WG-299C dc/ac-ohms probe and cable, and provides for the measurement of rf voltages up to 250 Mc. The WG-301A can be used to check relative signal levels in receiver oscillators and low-power exciter stages. With this probe combination, it is not usually possible to measure the rf-signal voltages in power oscillators and amplifiers because the peak values of such voltages are relatively high. Before making rf measurements, make sure that estimated signal voltage values do not exceed the input-voltage ratings of the probe.

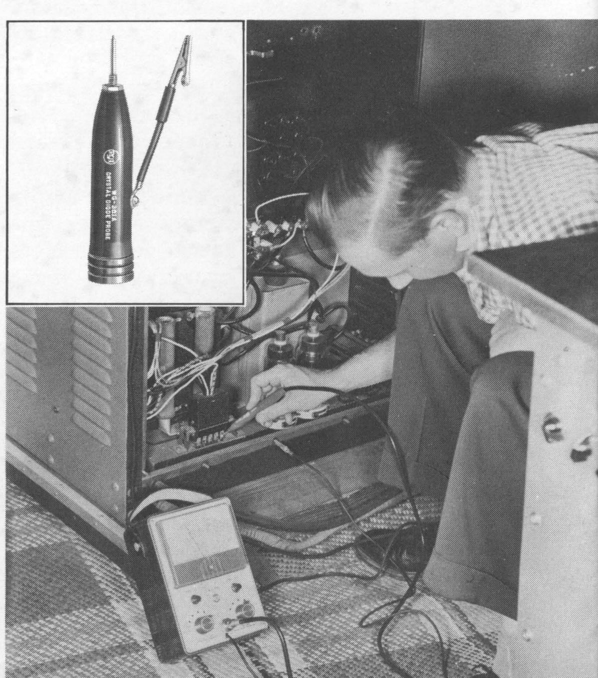
Bias Measurements

Bias-voltage measurements are important in transmitter stages inasmuch as the bias level determines the class of operation of the stage and greatly affects the drive requirements, power output, and harmonic content. Depending upon the class of amplifier, bias is adjusted to a cutoff or beyond cutoff value. In class C amplifiers utilizing fixed bias, the bias is adjusted so that no plate current flows when excitation is removed. Under class AB_1, AB_2, and B conditions, however, some plate current will flow under key-up conditions. For plate-modulated class C operation, bias is customarily increased to approximately two and one-half times the amount required for plate-current cutoff.

Some of the typical arrangements used to obtain grid bias are shown in Figure 2. In all arrangements, except that of Figure 2-F, the chassis (ground) is the reference point because the cathodes are grounded. Read the bias on the "—DC VOLTS" scales of the VoltOhmyst. In the illustrations, the operating bias (E_{op}) is the total amount of bias supplied or developed under driving conditions. Fixed or protective bias (E_{pr}) is used in the circuits shown in Figures 2-B, 2-C, 2-D, and 2-E. The operating bias in these circuits is made up of the total of the amount of fixed bias plus the bias developed when grid current flows through the grid resistor, if used. In all of the above illustrations, total bias is measured between point X in the grid circuit and the chassis.

Not all grid-circuit arrangements in transmitters contain an rf choke or rf bypass capacitor, and the accuracy of the bias measurement under key-down conditions will depend upon the amount of driving power and VTVM stability under rf conditions.

Figure 1. W2IYG uses WV-77C Junior VoltOhmyst with the WG-299C probe and cable to measure 400 volts for driver stage of his 800-watt transmitter. The WV-77C when used with the WG-299C has an input resistance of 11 megohms on all ranges, and will measure voltages up to 1200 v dc. Inset shows WG-301A crystal diode probe for measuring rf voltages up to 250 Mc. The WG-301A slips over the front end of the WG-299C.



High-Voltage Measurements

The maximum dc-voltage limit of the RCA WV-77C VoltOhmyst is 1200 v; for the WV-87B and WV-98A, 1500 v. To amateurs, the high-voltage probe can quickly become an indispensable measurement accessory. When making high-voltage measurements, first remove all B+ voltages from the transmitter. Next, with probe and ground cable properly connected to the VoltOhmyst, connect the ground clip of the probe to the transmitter chassis. Then, connect the tip of the probe to the high-voltage test point. If measurements and circuit adjustments are to be made simultaneously, clamp or tape the probe tip firmly in position. Next, make sure the VoltOhmyst is set up for plus dc-voltage measurements and that a suitable voltage range is selected. Apply plate voltage, screen voltage, and grid drive to the amplifier. Because the high-voltage probe attenuates the input voltage by a factor of 100, multiply the meter reading by 100 to obtain the true voltage measurement.

The voltage regulation of the power supply may be determined by measuring its output voltage under two conditions: (1) with no excitation applied to the amplifier without load and (2) with excitation applied to the amplifier with load. The percent change in output voltage between zero load and load is the voltage regulation. As the load increases, the output voltage will tend to decrease.

The plate power input to the amplifier stage can be determined simply by multiplying the plate voltage as read on the meter scale by the total amount of plate current in amperes drawn from the supply.

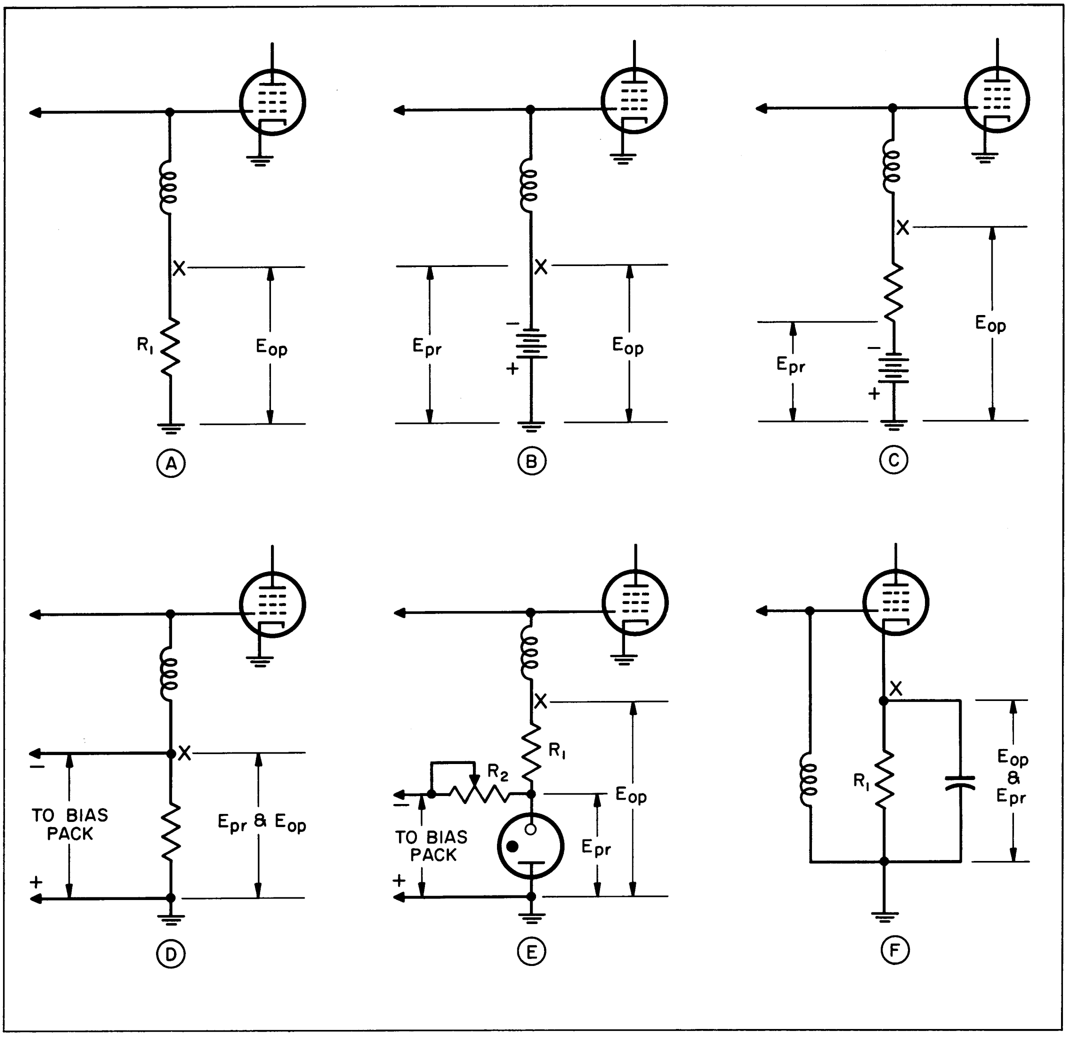


Figure 2. Typical arrangements used to obtain grid bias.

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Harvey Slovik, Editor
Robert Leedy, W2PMP
Technical Editor

FORM 3547 REQUESTED.

Here's an *Automatic* Tube Tester for the Shack

The "test-it-yourself" ham is going to be interested in the new RCA WT-110A *Automatic* Electron-Tube Tester which was recently announced and is now available from your local RCA distributor. The WT-110A is capable of testing a wide variety of receiving-type tubes used in amateur transmitters, receivers, and test instruments. The new tube tester will check interelectrode shorts and leakage, gas condition, and general quality.

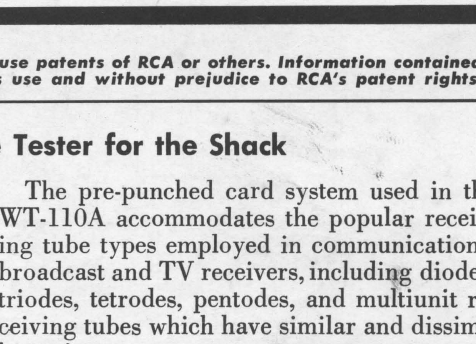
General quality testing is based on measurement of the transconductance of the tube. Readings are provided in terms of "Renew—?—Good" on a 4½-inch meter. The gas condition is also indicated on the meter.

Tube-pin and test voltage connections are automatically set up in the WT-110A by inserting individual pre-punched computer-type information cards in a slot on the front panel of the instrument. There is a separate card for each tube type.

The new tester comes supplied with a set of 239 of these pre-punched cards for 7-pin and 9-pin miniature, octal-, and lock-in-type receiving tubes. Unpunched cards and a punch are available as accessories to enable the amateur to make his own test cards.

The pre-punched card system used in the WT-110A accommodates the popular receiving tube types employed in communications, broadcast and TV receivers, including diodes, triodes, tetrodes, pentodes, and multiunit receiving tubes which have similar and dissimilar units.

In addition, the WT-110A has special provision for making high-resistance interelectrode leakage and low-value gas-current tests on certain tube types. These special tests make possible a better evaluation of tube types used in applications critical to leakage or gas.



HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. XVIII, No. 1 FEBRUARY,1958

HAM SHACK TROUBLE-SHOOTER

Practical Applications of the Versatile RCA VoltOhmyst

by Rhys Samuel, W2GOQ

RCA Electron Tube Division, Harrison, N. J.

This feature concludes the two-part article covering the use of vacuum-tube voltmeters in the ham shack and covers a few of the many applications in which *VoltOhmysts®* can be used. The examples shown below serve to illustrate the measurement principles and techniques utilized for specific equipment, but they can be applied, in general, to similar types of equipment.

Checking Oscillators

The VoltOhmyst* can be used to check all operating voltages under key-up or key-down conditions in both types of oscillator circuits shown in Figure 1. The measurement principles involved in these representative circuits can be applied to any type of oscillator.

A complete check of the operating voltages includes measurement of ac heater voltage, control-grid voltage, screen-grid voltage, and plate voltage. To measure the heater voltage, connect the ground cable to the chassis (ground) if one end of the heater supply is grounded, or to one side of the heater and connect the probe to the other side of the heater. Always make heater-voltage measurements directly at the tube pins. Faulty solder connections or IR drop in heater-lead wiring can cause insufficient voltage at the tube socket, although normal voltage can be measured at the transformer.

In tetrode and pentode oscillators, screen voltage influences overall performance of the stage. In keyed oscillators, measure the plate and screen voltages under both key-up and key-down conditions. Unless a voltage-regulated power supply is used, the key-down voltage will be less than the key-up voltage.

If the oscillator delivers much power, measure the plate voltage at point D in either of the circuits of Figure 1, rather than at point E, to prevent the strong rf signal from affecting the voltage reading. The capacitor from point D to ground serves to keep rf energy from getting into the supply lead and permits the measurement to be made. Because no dropping resistor is used in the plate circuit, the dc voltage measured at point D should be the same as at point E. Plate current will increase with off-resonance tuning and cause a change in the dc voltage at the tube.

Measure the screen voltage at point C, which is at rf ground potential because of the screen bypass capacitor, If a considerable amount of power is being drawn from the oscillator, make sure that screen voltage does not exceed the permissible rating for the tube when the key is up. The degree of voltage change under keying depends upon power-supply regulation.

The amount of developed grid bias is a good indication of how the stage is function-

*"*VoltOhmyst*" is a registered trademark of the Radio Corporation of America.

ing; the amount of bias voltage will increase with the strength of oscillation. The dc probe can be used to check bias at point A. This voltage is negative with respect to the cathode and is measured between the control grid and cathode of the oscillator stage. Bias will decrease as the plate load is increased.

Amplifier and Multiplier Stages

It is equally important that the operating voltages of amplifier and frequency-multiplier stages be set correctly to prevent damage to tubes and to minimize generation of harmonics and parasitics. The typical amplifier stages shown in Figure 2 differ in their input-coupling arrangements and plate-feed methods. Plate-circuit tuning in both these amplifiers will affect the grid, screen, and plate-current flow and will generally affect the voltage levels at the tube. The bias voltage measured at point A in both circuits, for example, will depend upon the amount of drive and, in triode amplifiers, upon plate-circuit tuning. Grid-circuit tuning will also affect the amount of measured bias. Bias voltage will increase with excitation and will be greatest at grid-circuit resonance.

In amplifier stages, measure operating voltages under both key-up and key-down conditions. If an appreciable amount of current is drawn by the amplifier tube, the plate, screen, and bias voltages can change over a relatively wide range. Under these conditions, it is important to prevent the screen voltage from rising to a value which exceeds the screen-dissipation rating of the tube, especially in circuit 2B. The VoltOhmyst can be used to measure the dc voltages at points C in both circuits under key-up and key-down conditions.

DC-voltage measurements at point A will provide an exact indication of the total bias. Plate voltages should be measured at point D in the circuit. Because different amplifier arrangements utilize different types of bias circuits, no single method of measuring bias will suffice for all arrangements.

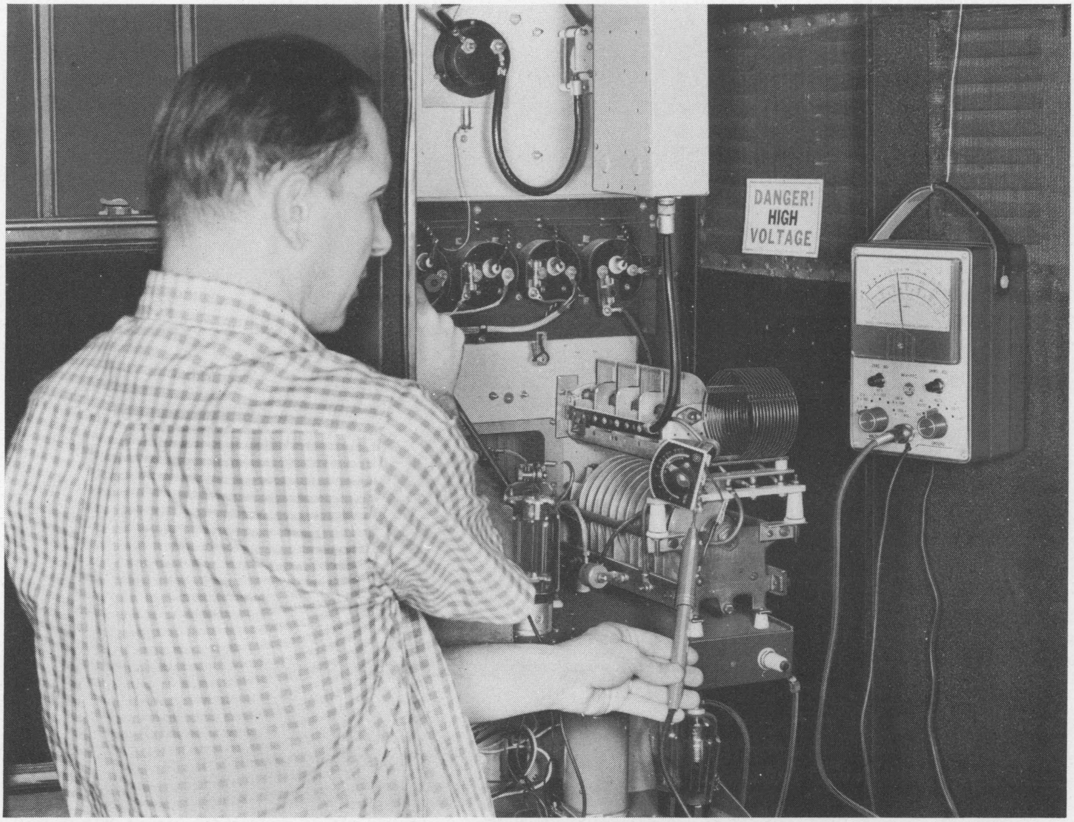
Adjustment of High-Power Amplifiers

Measurement of operating voltages in high-power amplifiers deserves special consideration for several reasons. For example, the high plate and screen voltages employed are hazardous, and measurement techniques must take into account the possibility that high voltages may appear at unexpected points because of insulation breakdown in the transmitter. Also, misadjustment of tuning controls or operating voltages may damage costly tubes and components, especially when newly constructed equipment is first tested.

While the transmitter circuit shown in Figure 3 may differ considerably in design from those found in many ham rigs, the measurement techniques and precautions described for it apply to all transmitter amplifiers. In all high-power equipment, checking and adjustment of ac filament voltages is especially important to tube life and performance. Grid-bias voltages are equally important because they have a direct effect upon the screen and plate dissipation of the tube under key-up conditions. The value of the grid-bias voltage also affects drive requirements and sets the operating level (class of operation) of the amplifier. In tetrodes, screen voltages should be carefully adjusted to insure that screen dissipation is kept within proper limits under both key-up and key-down conditions. Plate voltages, as well as plate current, should be determined exactly when the operating level borders on the legal input-power limit or the maximum permissible ratings for the tube type.

Preliminary Checks

In setting up an rf amplifier for the first time, use the VoltOhmyst to make precautionary measurements before applying plate and screen voltages. When checking out a high-power amplifier, such as that shown in Figure 3, use the following procedure: (1) Apply filament and grid-bias voltages. Remove excitation. (2) Set up the VoltOhmyst for ac-voltage measurements. Check the filament voltage of each tube directly at the filament pins (xx) and (yy) by connecting the ground cable to one pin and the ac probe to the other pin at the same tube socket. Filament voltage should be within at least ±5% of the recommended voltage for the tube type. (3) If the voltage measured at either filament is off by more than ±5%, measure the line voltage on the primary side of the filament transformers. If line voltage is correct, IR drop in the filament wiring may be responsible. In this event, replace the wiring with heavier conductors. It is also possible that one of the filament transformers may need replacement because of improper turns ratio. (4) Check the fixed grid bias by setting up the VoltOhmyst for "—DC" voltage measurements and read the voltage directly at the grid pins of both tubes. This is a wise precaution, especially in equipment which is not protected against grid-bias failure. If proper voltage is measured for both tubes, the wiring is correct and the fixed-bias supply is functioning properly.



When connected to a wavemeter circuit, the VoltOhmyst makes an excellent rf-tuning indicator. Here, W2IYG uses the WV-77C and WG-301A Crystal-Diode Probe during neutralizing of final amplifier.

The separate bias-supply leads feeding the two halves of the grid circuit in Figure 3 are provided as a means of checking the balance of the push-pull circuit. Do not attempt to measure total grid voltage at the grid pins when excitation is applied because of the high rf grid voltage. (5) Adjust the grid-tank tuning and the coupling to obtain the required amount of grid current in both grid-circuit legs. Remove excitation. (6) The amplifier can now be checked for plate-current cutoff or, if it is to be operated class AB or B, for the required amount of static plate current. With fixed bias applied and excitation removed, apply plate and screen voltages. Note the plate current flow, if any, and adjust the bias voltage from the supply to give the required cutoff or static current. Remove the high voltage. (7) The plate and screen circuits can now be checked with excitation applied and with the amplifier under dummy load. In circuits which employ high-perveance tubes, take care to prevent excessive plate and screen current flow while tuning. Unless dial settings of plate-tank resonant points are first established by means of a grid-dip oscillator, use a considerably reduced plate voltage for tuning. Measure the plate voltage at point C and the screen voltage at point D. The rf choke and capacitor C5 will keep rf out of the VoltOhmyst at point D. Point C is likewise at rf ground potential because of the rf choke and bypass capacitor.

The basic measurement procedures just described should provide a thorough and reliable check of equipment operating conditions and adjustments. When voltage measurements indicate improper operation or component failure, the VoltOhmyst can be set up quickly for resistance measurements and for conventional trouble-shooting.

Miscellaneous Applications

The filtering action of power-supply filters may be determined easily by measuring the ac component at the output of the filter. The VoltOhmysts are well suited to this application because of their ability to measure ac in the presence of dc voltages.

Ripple is measured by setting up the VoltOhmyst for ac-voltage measurements on a

low-range scale, connecting the ground cable to the negative side of the power-supply filter section, and connecting the probe to the positive side. Figure 4 shows the setup and a representation of the ripple and dc components of the output voltage. The VoltOhmyst will indicate only the rms value of the ripple component.

The effectiveness of the filter can be expressed in terms of percent of ripple, which is the ratio of the rms value of the ripple voltage to the value of the dc voltage multiplied by 100. For example, if the dc voltage is 250 v and the measured ripple voltage is 1.25 v, the percentage of ripple is 0.5.

Power-supply regulation can be determined simply by measuring the dc output voltage under load ($E_{minimum}$) and no-load ($E_{maximum}$) conditions. Percentage of regulation is equal to:

$$\frac{E_{maximum} - E_{minimum}}{E_{maximum}} \times 100$$

Neutralization Indicator

When used in conjunction with the WG-301A crystal-diode probe, the VoltOhmyst can be employed as a neutralizing indicator in power-amplifier stages. Amplifier neutralization is normally accomplished with plate voltage removed and with excitation applied. If the amplifier is not properly neutralized, some rf energy will appear in the plate-tank circuit. Proper adjustment of the neutralizing capacitors in the amplifier will eliminate the rf from the plate circuit.

A neutralizing setup which employs the VoltOhmyst as an rf indicator is shown in Figure 5. Set the VoltOhmyst to its lowest dc-voltage range and attach a small wire loop to the tip of the WG-301A probe. Make sure the amplifier plate voltage is off. Couple the loop tightly to the plate-tank coil. Apply excitation and tune the plate-tank capacitor near the resonant point until a reading is obtained on the VoltOhmyst. Adjust the neutralizing capacitors equally until no reading or a minimum reading is obtained on the VoltOhmyst. It is usually necessary to retune slightly to maintain a reading on the VoltOhmyst because adjustment of the neutralizing capacitors changes the tuning point at which the rf indication occurs.

Wavemeter—Field-Strength Meter

The VoltOhmyst and WG-301A probe can also be used in combination with a tuned circuit as a wavemeter and field-strength meter, as shown in Figure 6. This arrangement is especially useful in determining the frequency of an output signal, in checking for radiation from transmitters, and in plotting the radiation patterns of antenna systems.

The tuned circuit consists simply of a coil and capacitor which can be adjusted to the operating frequency. The coil is tapped about one-third of the length along its turns. Set up the VoltOhmyst on its lowest dc-voltage scale and connect the WG-301A crystal-diode probe to the coil tap. Adjust the tuned circuit for maximum reading on the meter. It may be necessary to experiment somewhat with the length of the pick-up lead used on the wavemeter to obtain a suitable meter indication. In these applications, the readings obtained will be relative but useful, nevertheless, in making adjustments and checks.

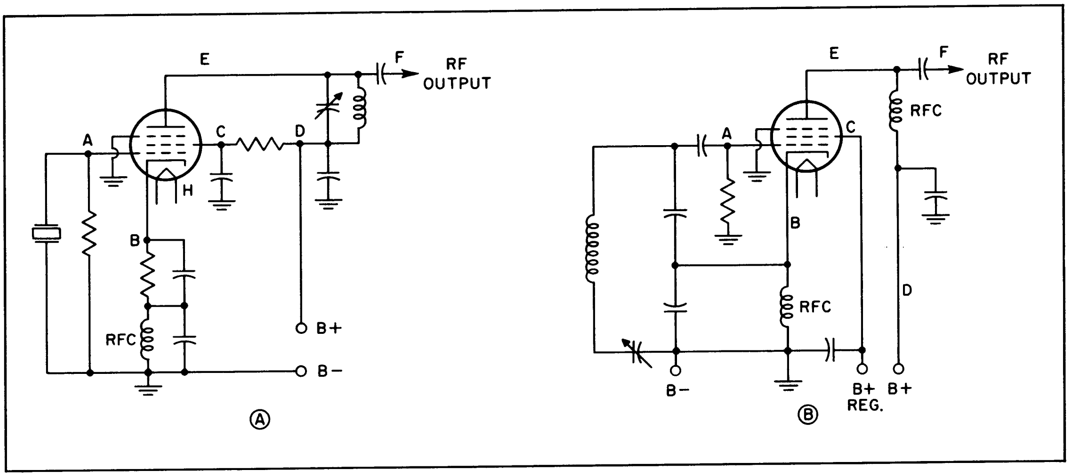


Figure 1. Typical oscillator circuits.

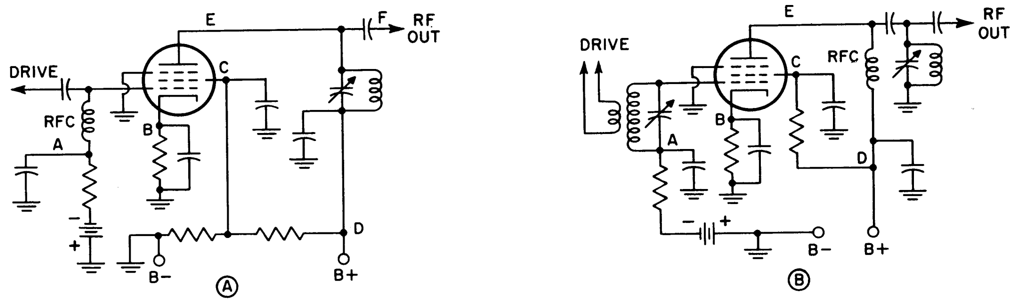


Figure 2. Typical amplifier stages.

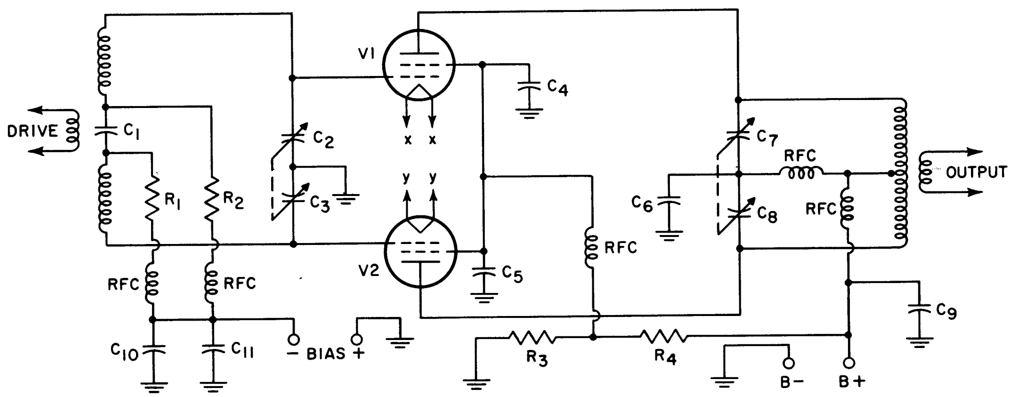


Figure 3. A transmitter final amplifier circuit.

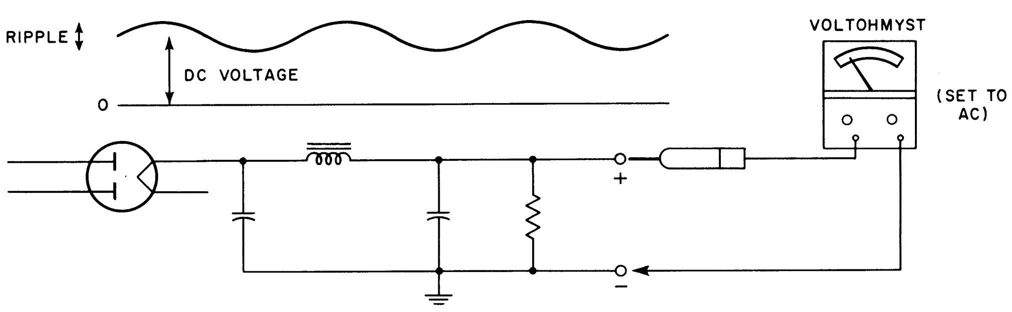


Figure 4. Measuring ripple voltage in PS output.

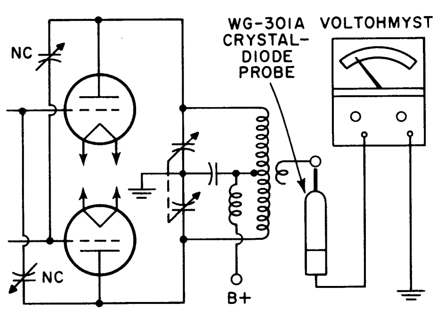


Figure 5. Neutralization of final amplifiers.

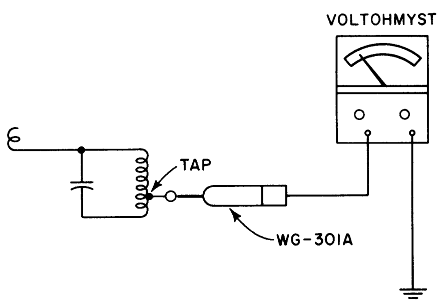
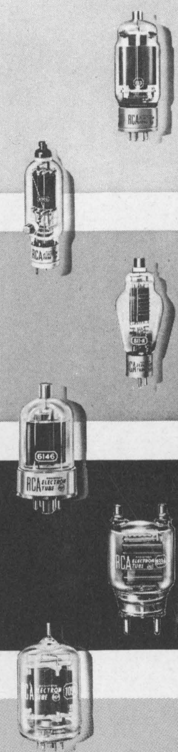


Figure 6. The VoltOhmyst used as a wavemeter.

RCA Tubes for Linear RF Power Amplifier Service (Single-Sideband, Suppressed Carrier)
(Arranged according to Power Output)

RCA Type	Class of Operation	Max. Frequency for full Input Mc	Heater (H) or Filament Volts	Typical Operating Conditions (Per Tube): DC Plate Volts	DC Grid-No. 2 Volts	DC Grid-No. 1 Volts	Peak RF Grid-No. 1 Signal Volts	Zero-Signal DC Plate Current Ma.	Max. Signal DC Plate Current Ma.	Approx. Max.-Sig. Driving Power Watts	Effective Load Resistance Ohms	Approx. Max.-Sig. Power Output Watts
6CL6	AB_1	60	6.3(H)	300●	150	−6	6	4.6	16	0	9100	3
6973	AB_1	60	6.3(H)	400	250	−24	24	8.4	33	0	5600	9
2E24	AB_1	125	6.3	500	210	−21	21	10	35	0	8300	11
1614	AB_1	80	6.3(H)	450	300	−35	35	14	50	0	5000	16
2E26 6893	AB_1 AB_1	125 125	6.3(H) 12.6(H)	500	210	−30	30	9	53	0	5370	17
837	B	20	12.6(H)	500	0#	0#	40	2.6	61	3.5	4630	21
807	AB_1	60	6.3(H)	750	300	−35	35	15	71	0	6250	35
1625	AB_1	60	12.6(H)	750	300	−35	35	15	71	0	6250	35
6816	AB_1	60	6.3(H)	850	300	−15	15	40	100	0	3500	40
6524■ 6850■	AB_1 AB_1	100 100	6.3(H) 12.6(H)	600	300	−33.5	67†	30▲	122	0	12100‡	50
6146 6883	AB_1 AB_1	60 60	6.3(H) 12.6(H)	750	180	−46	46	12	98	0	4640	52
809	B	60	6.3	700	—	0	72	35	118	8	3900	59
829-B■	AB_1	200	6.3(H) 12.6(H)	750	225	−25	50†	20▲	132▲	0	13640‡	68▲
805	B	30	10.0	1250	—	0	110	78	204	3.5	3560	155
828	AB_1	30	10.0	2000*	750	−115	95	25	116	0	10300	157
4X150A	AB_1	500	6.0(H)	1250	300	−50	50	57	202	0	3500	157
811-A	B	30	6.3	1500	—	0	85	13	150	13	6260	160
813	B	30	10.0	2500	#	0#	91	30	133	12	11000	219
6161	B	900	6.3(H)	1600	—	−57	82	80	239	18	3720	225
813	AB_1	30	10.0	2500●	750	−95	90	25	148	0	9660	245
7094	AB_1	60	6.3(H)	2000	400	−50	44	30	200	0	6000	280
7034	AB_1	150	6.0(H)	2000	300	−48	48	60	250	0	4270	290
833-A	B	30	10.0	3000	—	−70	165	50	328	5	5600	700

■ Twin Type
▲ Total Value per tube in Push-Pull application
† Grid No. 1 to Grid No. 1 Signal
# With Grids Nos. 1, 2 & 3 tied together at socket
* With −60 Volts on Grid No. 3
● With Grid No. 3 Tied to Filament Supply Center Tap
‡ Effective plate-to-plate value



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The *right* RCA Tube for your single-sideband amplifier is listed in this chart. For the power you want, simply read down the column on the right. For the corresponding RCA Tube type, read the column on the left. When you make your choice—let the Typical Operating Conditions be your guide.

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Technical Editor

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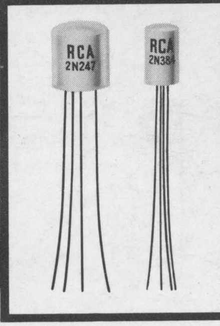
VOL. XVIII, No. 2 APRIL, 1958



A TRANSISTORIZED GRID-DIP METER

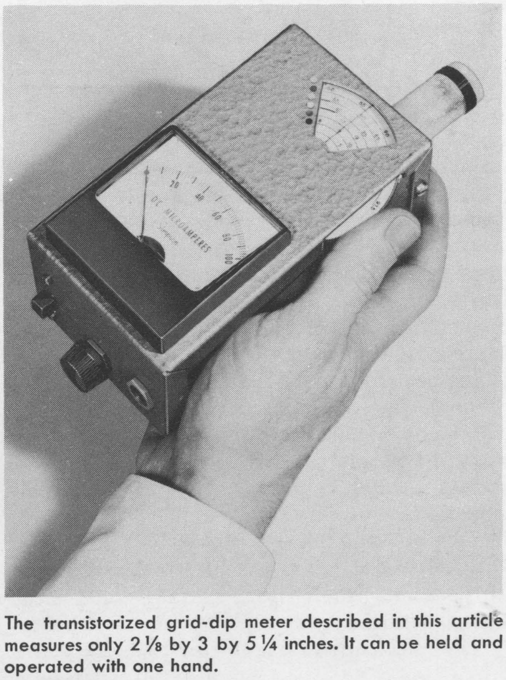
By Clarence A. West, W21YG

RCA Electron Tube Division, Harrison, N. J.

Like the VTVM, the grid-dip meter has become an important instrument, actually a necessity, for all serious-minded designers and builders of multiband communications equipment. In view of the fact that valuable tubes in a power amplifier can be ruined by operation of the amplifier with a plate tank circuit incapable of resonance, a grid-dip meter is inexpensive insurance. Because this instrument can also be used for other applications such as a wavemeter, signal generator, or field strength meter, an up-to-date amateur station can hardly afford to be without one.

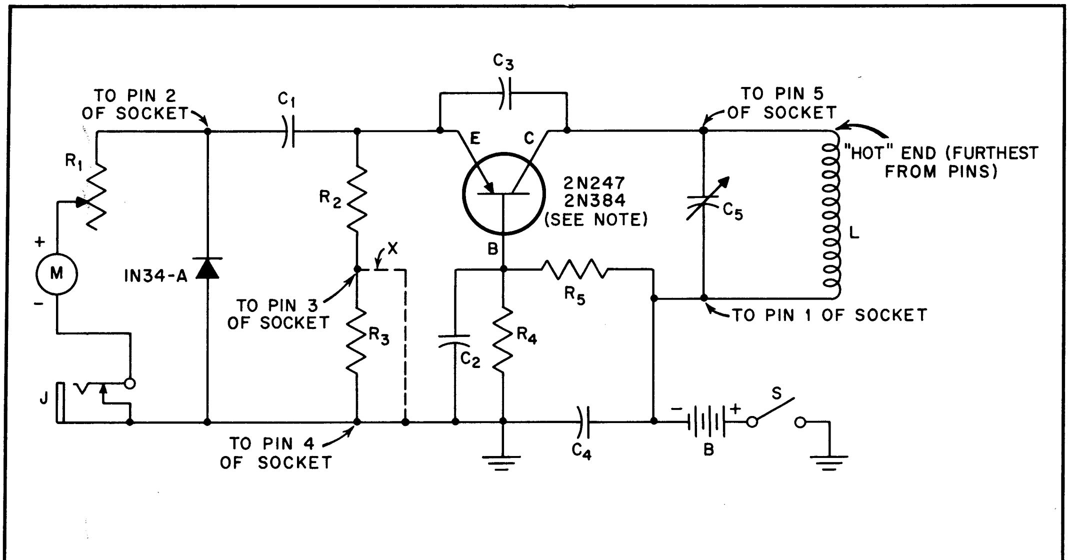
Part I of W21YG's two-part article, beginning in this issue, contains a description of the grid-dip meter designed and constructed by the author, along with details of its construction. A schematic diagram and parts list, as well as close-up views of the instrument, are also featured.

Instructions on the operation and use of this grid-dip meter will be given in Part II.



The transistorized grid-dip meter described in this article measures only 2 1/8 by 3 by 5 1/4 inches. It can be held and operated with one hand.

Basically, a grid-dip meter consists of an rf oscillator capable of being tuned over a wide frequency range, a visual indicator to show when energy is being absorbed from the oscillator tank circuit, and a source of power. Practically all grid-dip meters utilize an electron tube in the oscillator circuit with a low-range milliammeter or microammeter connected to read grid current. Their most common use is to determine the resonant frequency of de-energized tuned circuits. The grid-dip meter described in this article utilizes a high-frequency drift transistor (RCA type 2N247 or 2N384) in the oscillator circuit, a semiconductor diode (RCA type 1N34-A) and microammeter as an rf indicator, and a 13½ volt miniature battery, such as the RCA-VS304, as the source of power. Oscillation in the common-base oscillator circuit is sustained by the feedback capacitor C_3 (see Figure 1). Rf voltage in the emitter-base circuit is capacitively coupled through C_1 to a semiconductor diode, and the rectified output can be read on the dc microammeter M. When power is absorbed from



B—13½-volt battery (RCA-VS304)
C1—33 uuf, mica, 150 volts
C2—0.01 uf, paper, 150 volts
C3—5 uuf, mica, 150 volts
C4—0.01 uf, paper, 150 volts
C5—50 uuf variable (Hammarlund HF-50)
J—Phone jack, normally closed
L—Plug-in coil (see coil-winding chart)
M—0-50 microammeter (Simpson Model 1227)
R1—0.25 megohm, variable, 0.5 watt
R2—220 ohms, 0.5 watt
R3—3000 ohms, 0.5 watt
R4—3900 ohms, 0.5 watt
R5—39,000 ohms, 0.5 watt
X—Jumper to set emitter voltage: pins 3 and 4 of coils above 45 Mc (see text)

COIL-WINDING CHART

Coil	*Freq. Range*	*Wire Size*	*No. of Turns*
1	3.4-6.9 Mc	#28, enamel	48¼, close wound*
2	6.7-13.5 Mc	#24, enamel	22, close wound
3	13-27 Mc	#24, enamel	9⅛, close wound
4	25-47 Mc	#24, enamel	4⅛, close wound
5	45-78 Mc	#24, enamel	1½, close wound
6	74-97 Mc	#16, tinned	Hairpin formed, 1⅞ inches long, including pins, and ¼ inch wide

***All coil forms are Amphenol type 24-5H. For utmost in dial accuracy turns may be spread or compressed slightly before spraying.**

Figure 1: Schematic diagram, parts list, and coil table. Note that the 2N384 is for use at frequencies up through 100 Mc; the 2N247 for use at frequencies up through 50 Mc (including 6-meter band). The interlead shield is grounded.

the tuned circuit, L and C_5, rf feedback to the emitter is reduced and the microammeter shows a decreased reading. Some damping of the indicator circuit is provided by the emitter resistors R_2 and R_3.

Three desirable features for such an instrument are compactness, portability, and a self-contained power source. The low power drain and small size of the transistor used has enabled the instrument described in this article to have all of these features.

Measuring only 2⅛ by 3 by 5¼ inches, this grid-dip meter can be held and operated with one hand. It is compact and, therefore, capable of being closely coupled to tuned circuits in compactly designed equipment. It is completely portable and, being battery-operated, can be used anywhere. Because there is no heater to warm up, the instrument is instant-starting. Also due to the absence of heat, its frequency stability is excellent. Total power consumption is about 25 milliwatts! The instrument is relatively shock-resistant, and requires little maintenance. The transistor itself may never require replacement. The battery drain is so small that, with normal use, battery life for all practical purposes is "shelf life." Equally important, the instrument is very sensitive and accurate.

The RCA drift transistors, 2N247 and

2N384, are ideal for use in this instrument because they are designed specially for high-frequency applications. The 2N384 produces useful output in the circuit shown in Figure 1 at frequencies up through 100 megacycles. The 2N247 produces useful output in this same circuit at frequencies up through 50 Mc. These transistors may be used interchangeably in this instrument without circuit changes of any kind. The dial calibration remains accurate for either transistor.

Construction

The entire instrument is housed in a "Flexi-Mount" case measuring 2⅛ by 3 by 5¼ inches. All parts are mounted in the upper section of the case as shown in the photographs, Figures 2 and 3. It is suggested that the case be drilled and cut in the following steps to insure proper fitting of the parts. Cut the meter mounting hole first. A 2⅜-inch square meter, such as the Simpson Model No. 1227, is recommended. The meter hole should be cut ⅛ inch in from one end of the case and the meter temporarily mounted. Cut a piece of 3/32-inch polystyrene about 1⅝ inches wide and 2¾ inches long and drill two ¼-inch holes at one end to fit over the meter binding posts. This strip will serve as a mounting board for the tuning capacitor and other small parts. Next, cut two discs from 1/16-inch-thick polystyrene for the dial. Sandwich the printed dial, shown at right, between the discs, and fasten the discs by means of two small screws to a bushing having a ¼-inch diameter hole. Drill and tap the bushing to receive these screws. Make two cuts in the front right-hand side of the case far enough apart to allow the tuning dial to protrude about ¼ inch. Bend the cut-out piece under and lay the dial in place. A similar cutout is also required for the cover section of the case. Bolt the tuning capacitor to its mounting strip so that its shaft engages the dial bushing, as shown in Figure 3. Next, cut a window in the top of the case for use in viewing the dial. A piece of thin wire may be fastened across the dial window to provide a hairline.

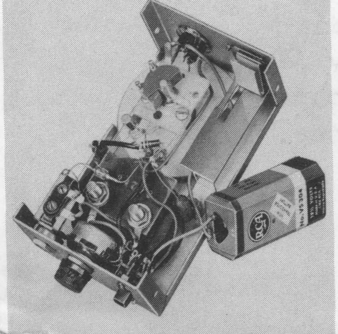
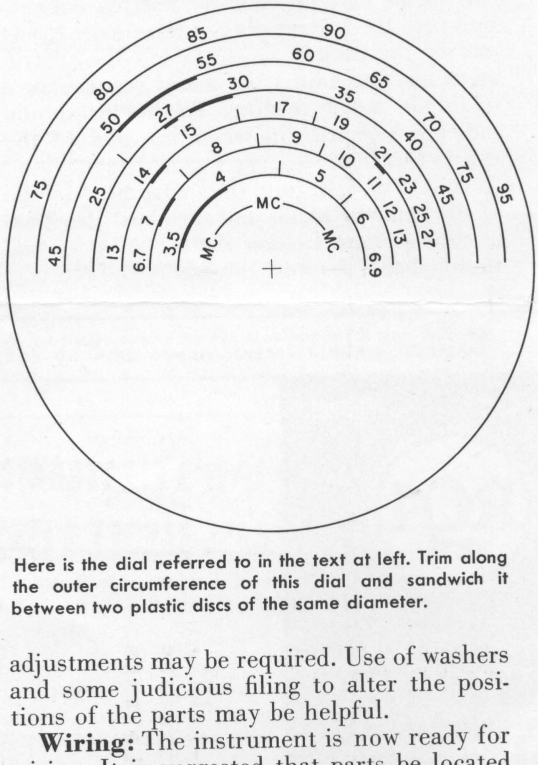


Figure 2: Bottom oblique right inside view of grid-dip meter showing parts layout. Battery has been removed to show battery mounting platform.

Mount the coil socket so that the rotor connection of the tuning capacitor contacts pin No. 1 of the socket, as shown in Figure 3. The meter control, phone jack, and switch are mounted at the rear of the case. Bend a ¾-inch-wide strip of metal to hold the battery as shown in Figure 2. Fasten one end of this strip to the front of the case and the other end to one of the meter mounting screws. A portion of the capacitor mounting strip should be cut away to make room for the battery. A folded strip of metal at the front of the case serves as a spring to hold the battery in place. The cover section of the "Flexi-Mount" box helps to secure the battery when the case is sealed.

Check to see that all parts fit into place and that the dial moves freely. Some minor adjustments may be required. Use of washers and some judicious filing to alter the positions of the parts may be helpful.



Here is the dial referred to in the text at left. Trim along the outer circumference of this dial and sandwich it between two plastic discs of the same diameter.

Wiring: The instrument is now ready for wiring. It is suggested that parts be located as shown in the photographs. Wiring is not critical; however, for dial accuracy, the two heavy leads connecting the tuning capacitor and coil socket should be kept short, as shown in the photographs. The polystyrene strip supporting the tuning capacitor may be used as a mounting board and drilled to accept leads from small parts including those of the transistor.

Coils: Coils are constructed according to the table shown in Figure 1. Pins No. 3 and No. 4 on each of the two high-frequency coils

(45 to 78 and 74 to 97 Mc) should be connected with a jumper to short out resistor R_3. This connection automatically sets the emitter voltage at the proper value when either of the high-frequency coils is used. Pin No. 5 of the coil form should be used for the end of the coil furthest from the pins. This arrangement puts the "hot" end of the coil in the best operation position. Following initial tests and adjustments, the coils should be sprayed lightly with a clear plastic spray. A dot of paint at the end of each coil form, with matching dots on the case next to the dial window, provides color coding to indicate frequency range of the coil in use.

Initial Tests and Adjustments: Check the wiring carefully before installing the 13½-volt battery. Two small pins like those on the coil forms may be used for making connection with the battery plug-in terminals. Insert one of the plug-in coils, switch the instrument on, and adjust the meter control for a mid-scale meter reading. The meter should indicate a sharp dip when the end of the coil is touched.

To set the dial, tune the instrument to one of the amateur bands and zero-beat its signal in the receiver. Loosen the set-screw on the tuning dial and adjust the dial to the receiver

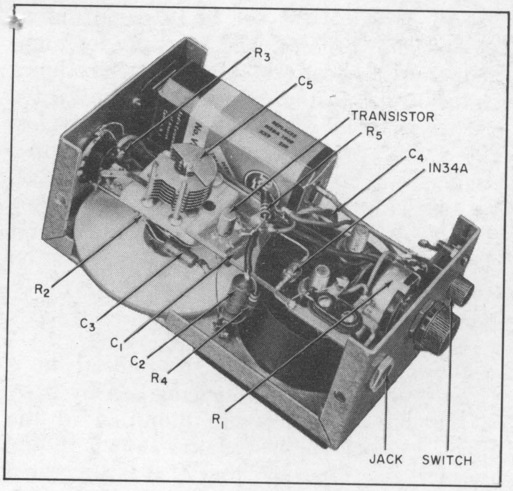


Figure 3: Bottom oblique left inside view of grid-dip meter showing parts layout and tuning capacitor mounting. Note cutout necessary to clear tuning dial.

frequency. Tighten the set-screw and check the other coils for accuracy. Increased dial accuracy may be obtained by spreading or compressing the turns on the coils. If the coils have been properly wound and the tuning capacitor mounted as described previously, dial accuracy approaches ±2%.

From your local RCA distributor, headquarters for RCA receiving and power tubes.

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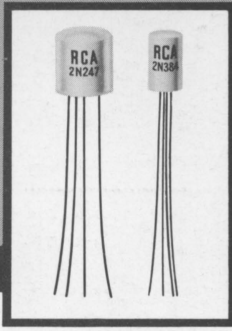


A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. XVIII, No. 3

JUNE, 1958

A TRANSISTORIZED GRID-DIP METER

Part II: Operation and Use

By Clarence A. West, W21YG

RCA Electron Tube Division, Harrison, N. J.

W21YG's two-part feature article began in the April, 1958, issue of HAM TIPS, which contained a description of the transistorized grid-dip meter designed and constructed by the author along with details of its construction. If you missed Part I, ask your local RCA distributor for a copy.

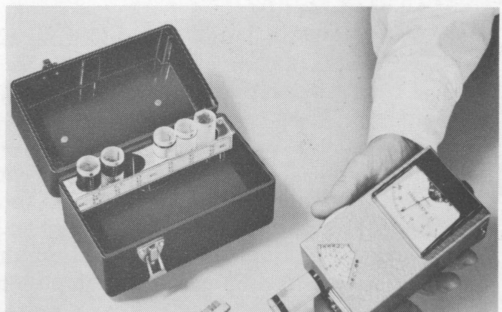
The transistorized grid-dip meter described in this article was designed primarily for determining the resonant frequency of tuned circuits quickly and with accuracy. To use the instrument for this application, estimate the approximate resonant frequency of the unknown tuned circuit and insert a coil having suitable frequency range. Switch on the instrument, adjust the meter control knob for a meter reading of about half-scale, and then tightly couple the coil to the unknown tuned circuit.

Keep both coils in the same plane for maximum coupling. Starting at one end of the tuning dial, rotate the dial slowly until a *pronounced* dip in meter reading occurs, then back the instrument off and tune through resonance again. Use loose coupling for accurate measurements, as indicated by a very small dip in meter reading.

Be sure the transmitter plate supply is turned off when "dipping" tank circuits in transmitters. There is danger of shock if this precaution is not observed.

The instrument may be used for many other applications including:

Signal Generator—To check the alignment of a receiver, tune the receiver, with AVC on, to a frequency at which no signals are present. Locate the instrument a few feet from the receiver at some convenient point along the receiver transmission line and tune to the receiver frequency as indicated by an "S" meter reading. Because there is no need to disconnect the line from the receiver, an accurate alignment check is provided with the



W21YG's transistorized grid-dip meter being used to measure the frequency of a tuned circuit. (Note instrument carrying case with coil-storage rack. The case is made from two plastic cases, such as Allied 86P286, fastened together with a small set of hinges. A handle and lock complete the case. The coil storage rack is cut from a thin sheet of aluminum and riveted or screwed into place. Coils and dial window are color coded to indicate frequency range of coil in use.)

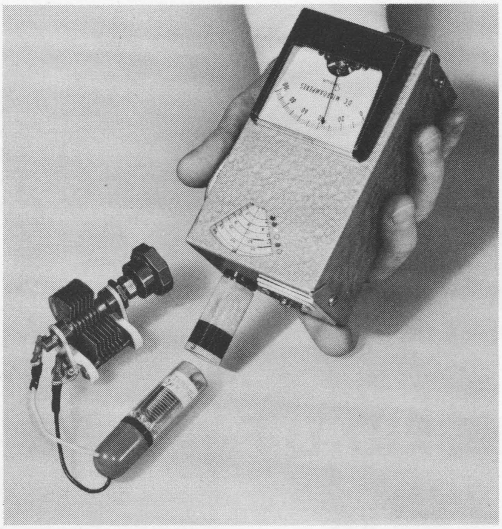


Figure 1: Use of author's grid-dip meter to measure value of an unknown capacitor. The standard inductance consists of 15¾ turns of B&W Miniductor #3003 (½-inch diameter, 16 TPI) enclosed in an Amphenol coil form type 24-5H. Note use of adapter with clip leads for connection to unknown capacitor.

existing antenna system and receiving conditions.

Field Strength Meter—Set the operating switch to the "off" position and connect a short length of wire to coil socket pin No. 2. *No coil is needed for this application* because the short length of wire serves as the pickup. The instrument can now be used to indicate rf voltages up through the VHF region. In this application, only the indicator portion of the instrument is utilized.

As an example of its use in loading an rf amplifier, couple the instrument loosely to the antenna transmission line by means of a short length of wire. Keep the instrument and pickup wire far enough away from the final amplifier tank to prevent excessive rf pickup from the tank itself. Tune and proceed to load the amplifier, observing the field strength meter. With increased loading, both the field strength meter and plate current meter of the amplifier will indicate increased readings. For maximum output, coupling should be increased until the field-strength-meter reading reaches its peak. With overcoupling, the plate current will continue to rise and the field-strength-meter reading will drop. Adjust the coupling to maintain the highest field-strength reading with the lowest plate current reading. Be sure to maintain resonance of the amplifier.

Monitor—Because the battery in the instrument is disconnected for *field-strength* use, the instrument may be placed conveniently anywhere in the shack and utilized as a visual monitor of all transmissions. Use a length of wire, as described previously, to serve as an rf pickup. A pair of high-impedance headphones plugged into the jack can be used for monitoring an amplitude-modulated signal.

Neutralizing Indicator – Using the instrument as a field-strength meter, couple the pickup wire to the plate tank coil of the amplifier stage to be neutralized. Plate and screen-grid voltages must be off, but full drive applied to the input circuit. Tune the plate tank circuit to resonance as indicated by maximum reading on the field strength meter. Adjust the neutralizing capacitor for minimum reading. If initial meter reading is too low, increase coupling to the tank by wrapping the pickup wire around the tank coil or by forming a single- or several-turn loop and returning the free end of the pickup wire to the instrument case or coil pin No. 4. Adjust the neutralizing capacitor for minimum rf indication.

Wavemeter—If it is desired to utilize this instrument as a wavemeter, a DPST switch should be used in place of the SPST switch shown in the circuit diagram in Part I. Wire the switch to open both the base circuit at the transistor and battery circuit when the switch is in the "off" position.

To check the output frequency of a trans-

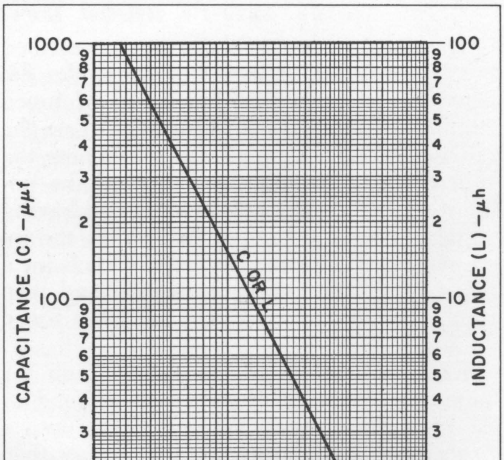


Figure 2: Chart for determining unknown values of L and C in the range 1 to 100 μh and 10 to 1000 μμf using an 18 μμf capacitor and a 1.3 μh inductance as standards.

mitter, insert a plug-in coil which will provide the instrument with the desired tuning range. The operate switch should be in the "off" position. Turn on the transmitter and *loosely* couple the wavemeter to the desired tank circuit. Tune the wavemeter for maximum meter reading. The tuning dial will indicate the output frequency of this stage.

Measurement of Capacitance or Inductance Values—The value of a capacitor in the range of 10 to 1000 $\mu\mu$f can be measured as follows: Connect the unknown capacitor across a 1.3 μh standard coil as shown in Figure 1. Starting with the lowest-frequency-range coil plugged into the instrument, de-

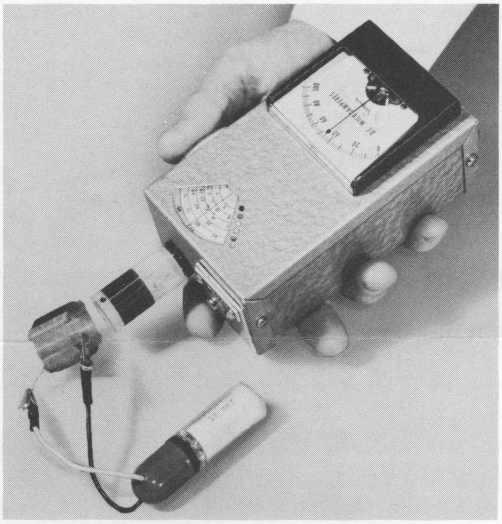


Figure 3: Use of grid-dip meter to measure an unknown inductance. A standard capacitor of 18 $\mu\mu$f is utilized. This standard capacitor is mounted inside an Amphenol type 24-5H coil form.

termine the resonant frequency of the standard coil and the unknown capacitor. When the resonant frequency is found, utilize the chart shown in Figure 2 to determine the value of the unknown capacitor. A capacitor of 100 $\mu\mu$f, for example, will resonate with the test coil at a frequency of 12.2 Mc.

The value of an inductance in the range 1 to 100 μh can be accomplished in a similar manner, except a standard capacitor of 18 $\mu\mu$f is utilized. Connect the standard capacitor across the unknown inductance, as shown in Figure 3, and determine the resonant frequency of this circuit. Utilizing the chart, determine the value of the unknown inductance. An inductance of 5 μh, for example, will resonate with the standard capacitor at a frequency of 17.5 Mc.

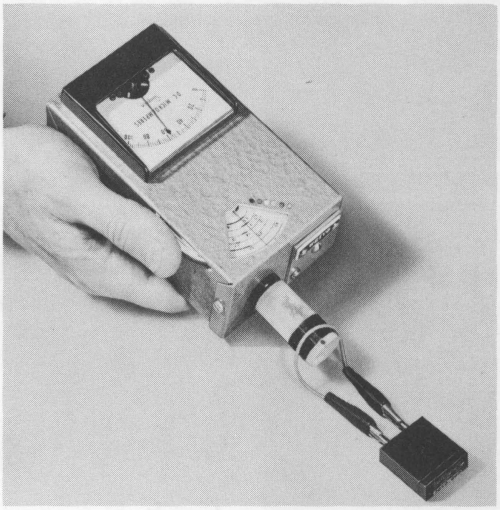
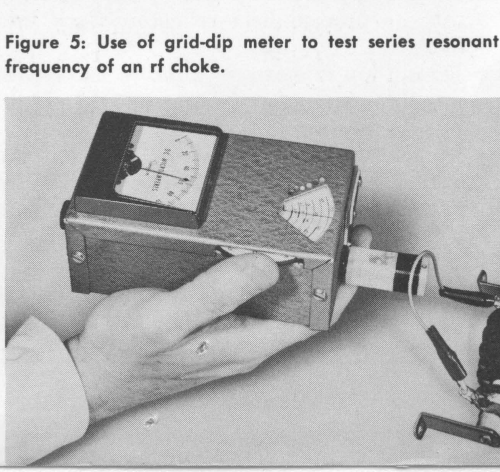


Figure 4: Use of grid-dip meter to test a quartz crystal.

Testing Quartz Crystals—The frequency of a quartz crystal may be determined by connecting a short length of wire to each of the crystal holder pins to form a small loop (see Figure 4). Couple the grid-dip meter coil tightly by inserting the coil inside the loop of wire. Tune the instrument slowly until a dip occurs, then loosen the coupling and re-"dip" the circuit. Read the crystal frequency on the tuning dial. This test also indicates activity of the crystal. The meter will not dip with an inactive crystal.

Checking RF Chokes for Self-Resonance—It is important that rf chokes used in parallel or shunt fed circuits be free of series resonance over the operating frequency range of the circuit to prevent their burning out. The popular pi-tank circuit is such an example in which the rf choke is shunted across the full rf output of the tube. To test the choke for series resonance, short-circuit the choke and determine its resonance frequencies with the grid-dip meter, as shown in Figure 5.

Figure 5: Use of grid-dip meter to test series resonant frequency of an rf choke.



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Technical Editor

Longer Life for Your RCA-6146 Beam Power Tube

Due to the extreme popularity of the RCA-6146 beam power tube among hams, HAM TIPS again presents a few do's which should help you to considerably increase the already long life of this type.

- Hold heater voltage at 6.3 volts—at tube terminals.
- Provide for adequate ventilation around tube to prevent tube and circuit damage caused by overheating.
- Keep shiny shielding surfaces away from tube to prevent heat reflection back into tube.
- Design circuits around tube to use lowest possible value of resistance in grid circuit and screen circuit.
- In high frequency service, operate tube under load conditions such that maximum rated plate current flows at the plate voltage which will give maximum rated input.
- Have overload protection in plate and screen circuits to protect tube in the event of driver failure.
- See that plate shows no color when operated at full ratings (CCS or ICAS conditions).
- Reduce B+ or insert additional screen resistance when tuning under no-load conditions to prevent exceeding grid-No. 2 input rating.
- Maintain tuning and loading adjustments precisely so that tube will not be subjected to excessive overload. The 6146 is a high-gain, high-perveance tube and can be more easily overloaded through circuit misadjustments than older types not having such features.
- Use adequate grid drive, keeping within maximum grid-current and screen dissipation ratings of tube. Too little grid drive can cause high plate dissipation.
- Make connections to plate with flexible lead to prevent strain on cap seal.
- Operate 6146 within RCA ratings as shown in technical bulletin available on request from RCA Commercial Engineering, Harrison, N. J.

HAM TIPS
A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION
VOL. XVIII, No. 4 SEPT.-OCT., 1958

WHICH IS WHAT?

A Review of Some Modern Amplitude-Modulation Systems

by Kenneth W. Uhler*

Single sideband, synchronous detection, compatible single sideband! These and many other similar phrases appear in many of today's publications. But too often the advantages claimed for one of these systems in the article you are currently reading conflict with the claims made for another system featured in the article you read last week. This seeming confusion leaves the reader with the question: "Which is what?" Hence, this article – intended as a review of the basic systems in the hope that it will lead to a better understanding of the published material.

Before a comparison of amplitude-modulation systems is made, however, some of the terms used in this article should be defined. The symbols are derived from the terms used and refer to frequencies, not magnitudes.

The radio frequency to be modulated is referred to as the carrier and the symbol is f_c. Similarly, this article is concerned with radiotelephony, where the modulating signal is the voice, and the symbol used is f_v.

Amplitude modulation can be defined as the process of varying the amplitude of a carrier at an audio rate. The result is that two new frequencies, (f_c+f_v) and (f_c-f_v), are produced.

For example, if the carrier frequency is 14 Mc, and it is modulated by an audio frequency of 1000 cycles:

$$\underset{(f_c)}{14{,}000{,}000} \text{ modulated with } \underset{(f_v)}{1000} \text{ will give:}$$

$$\underset{(f_c+f_v)}{14{,}001{,}000} \text{ and } \underset{(f_c)}{14{,}000{,}000} \text{ and } \underset{(f_c-f_v)}{13{,}999{,}000}$$

The sum of the two frequencies (f_c+f_v) is referred to as the upper sideband and the difference between the two frequencies (f_c-f_v) is referred to as the lower sideband.

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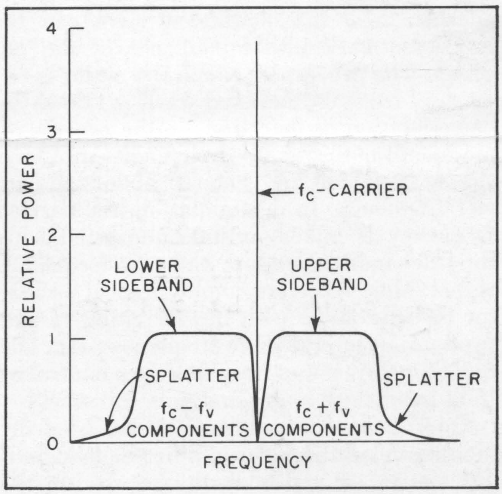

Figure 1: amplitude modulation.

AM (Both Sidebands and Carrier)

In the example of amplitude modulation given above, the modulated signal consists of

three frequencies: the lower sideband (f_c—f_v), the carrier (f_c), and the upper sideband (f_c+f_v). Figure 1 illustrates a frequency versus power curve for AM. The width of the sideband is dependent on the highest audio frequency used to modulate the carrier.

One of the common methods of obtaining amplitude modulation utilizes the fact that a power tube when operated Class C has a generally linear output for wide variations in plate voltage. Modulation is accomplished by inserting the audio signal in series with the plate of the tube.

No practical modulating system is without some non-linearity, and non-linearity, however small, leads to the generation of some unwanted frequencies. Because the plate tank has a relatively low Q when loaded and, therefore, relatively poor selectivity, all the unwanted frequencies generated are not filtered out. When these unwanted signals appear outside of the desired band, they can create very undesirable interference.

The AM system is not complete until we consider how the modulated wave can be translated back into intelligence at the receiver. The process by which the audio is recovered from the radiated wave is known as demodulation or detection. In the process of modulation, the audio frequencies produce sidebands which are centered about the carrier frequency. In demodulation, the carrier frequency is mixed or intermodulated with the sidebands to produce an audio frequency signal. Most receivers employ a local oscillator to heterodyne with the incoming rf and produce an intermediate frequency (if). The fixed-tuned if stages provide easier control of both bandwidth and gain.

One of the most common methods of demodulation utilizes the unidirectional characteristics of a diode which provide the non-linearity needed to intermodulate the carrier with the sidebands. One product of the intermodulation is the audio frequency. The unwanted sideband, carrier, and higher-frequency products are filtered out in simple RC circuits.

The diode demodulator has two distinct disadvantages. First, it has no gain, and the desired signal is usually attenuated 10% to 20% because rf filtering is required. Second, the desired modulation component becomes distorted at low signal levels and high percentages of modulation.

The complete AM system is subject to another commonly experienced phenomenon known as selective fading. Briefly, selective fading is a reduction in signal strength of a part of the band of frequencies transmitted. It can affect the amplitude and/or phase relationship between the carrier and either or both of the sidebands. This distortion in ordinary receivers often results in a significant loss of intelligibility.

The primary advantages of AM systems, as described, lie in their simplicity and low cost. Moreover, many practical techniques have been developed which greatly enhance the usefulness of AM. Improved bandwidth control and oscillator stability, better noise limiting and blanking circuits, and heterodyne detectors are all widely used in new receiver designs. The heterodyne detector, for example, produces much lower-order distortion for small-signal inputs than any of the simpler diode circuits, and can handle high percentages of modulation. This detector mixes a local oscillator signal with the radio frequency or intermediate frequency to produce an amplified audio signal.

Speech clipper and modulator design in the transmitter also can be greatly improved, and at only small additional cost and complexity. In comparing "new" systems to "ordinary" AM, one should be careful to determine how much of the advantage offered by the system comes from improvements that could be added to any system.

DSB (Both Sidebands, No Carrier)

"Double sideband" is also referred to as synchronous AM. The term "synchronous AM" comes from a method used to detect amplitude modulation. Basically, this method uses a heterodyne detector which demodulates directly to audio by mixing the modulated rf with a local oscillator signal. The local oscillator signal must be synchronized (in phase) with the original carrier to prevent unwanted phase distortion.

One such proposed system demodulates in two simultaneous heterodyne detectors. The local oscillator signal fed to one of them is phase shifted 90 degrees, so that the audio-output signal from this detector is zero.

When the local oscillator is phase locked (exactly in phase) to the original carrier frequency, the phase-shifted heterodyne output will remain zero. If the local oscillator is not in exact phase with the original carrier, the shifted detector will have an audio output proportional to the phase difference. This signal is used to provide a correction voltage for an automatic-frequency-control circuit. The frequency of the local oscillator is con-

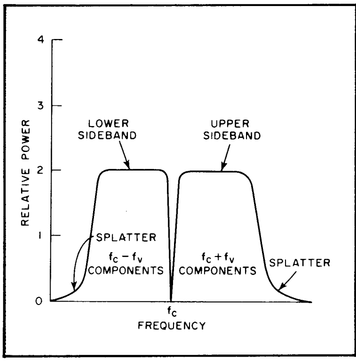

Figure 2: double sideband.

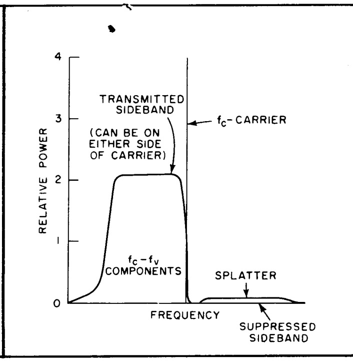

Figure 3: compatible SSB.

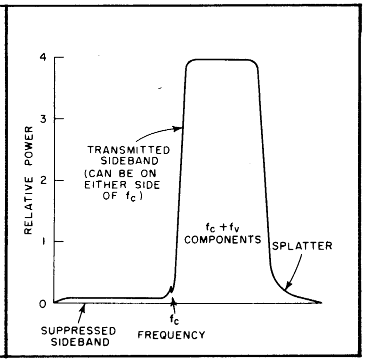

Figure 4: single sideband.

trolled at the apparent carrier frequency, reducing the effect of any selective fading present.

The principal advantages of this system come from the fact that no carrier is needed and the single receiver oscillator is frequency controlled. Of all the systems, synchronous AM is the least affected by selective fading.

Figure 2, drawn to the same scale as the AM diagram in Figure 1, points out the increased sideband power available for DSB operation without taking into account possible transmitter redesign. Balanced modulation in the transmitter will reduce the carrier level at least 30 db without special circuits of any kind. Balanced modulation is usually accomplished by using a push-pull final, which retains one of the advantages of AM in that it allows plate modulation of the final.

Two distinct advantages are inherent in the double-sideband system: 1) Reduction of the carrier eliminates the most annoying source of a continuous beat-frequency whistle interference produced by a co-channel station which reduces signal intelligibility and produces operator fatigue to a far greater degree than the "monkey chatter" of sideband cross-modulation products. 2) The final power amplifier is generally operated Class C in a balanced circuit so that rf power is produced only when modulation is present.

Compatible SSB (Single Sideband With Carrier)

The compatible single sideband system—currently being used by the "Voice of America" and WMGM – can be received on the present ordinary diode detector receivers. Balanced modulation is used to suppress the carrier, as in synchronous AM. One sideband is then filtered out and a controlled amount of carrier reinserted.

Compatible SSB can be represented as shown in Figure 3. Either sideband can be used. This system is subject to selective fading much in the same manner as conventional amplitude modulation, and is somewhat more susceptible to fading than AM and synchronous AM because the single sideband does not afford the redundancy of the double sideband. The advantages of this system are very important in applications like the "Voice of America" and other ground-to-fixed-station systems because of the following characteristics:

(1) Half the normal AM bandwidth.

(2) Compatible with existing receiving equipment.

(3) Allows increased efficiency in high-power transmitter design.

SSB (Single Sideband, No Carrier)

SSB goes all the way and transmits only one sideband, as shown in Figure 4. The lack of a carrier eliminates the whistle type of co-channel interference.

The bandwidth is the same as the bandwidth of the modulating frequency. The signals handled in the transmitter final are entirely modulation components. RMS power ratings become somewhat meaningless because voice modulation has such a complex waveform. For this reason, SSB finals are usually rated in terms of peak power capability. Balanced modulators are used to reduce the carrier at least 30 db. Phase networks, or filters, can be used to remove the unwanted sideband and further reduce the carrier.

Somewhat more complexity results from the low frequency used. Heterodyne circuits must be used to bring the signal frequency up to the rf region. Non-linear frequency multipliers, such as harmonic generator and

doublers, are not suitable because they would produce a high percentage of unwanted signals and distortion. Such circuits would also multiply the voice frequencies. This result would require complex frequency-divider circuits in the receiver.

The driver stages and final amplifier must be linear for the same reason. Efficiency of the final amplifier is considerably higher due to the fact that no carrier power is involved and the final can be designed to handle much greater peak power without exceeding the dissipation ratings. Because the zero signal condition exists until modulation is present, two-way single-channel communications are simplified (simplex operation).

The main disadvantages of the SSB system stem from the fact that demodulation must be accomplished by the addition of a demodulating signal at the receiver (often referred to as reinserting the carrier). Variations in the frequency of this injected signal will cause distortion of the voice frequencies that sound like a variable-speed phonograph. It is my personal opinion—through listening—that although this distortion is objectionable from a theoretical standpoint, it actually results in very little loss in intelligibility over a ± 150 cycle range. Critical applications are usually governed by a ± 50 cps maximum. The interference from an adjacent channel results in variable-pitch "monkey chatter" which can be tolerated even at quite high levels.

Selective fading becomes just plain fading in the case of only one sideband. The ability to select sidebands could provide the necessary redundancy to overcome this effect, but it would double the bandwidth.

The disadvantages of SSB are: (1) increased complexity, (2) tight frequency-drift specifications, (3) non-compatibility with existing equipment, and (4) both the transmitter and the receiver have tight linearity requirements. Cost is not always a factor. For equipments designed to produce the same degree of intelligibility between any two points, savings in power supply and tube cost make it entirely possible to build SSB equipment in the same price range as the comparable AM equipment.

The advantages of SSB, other than those associated with the improved circuitry, are: (1) narrow bandwidth and (2) improved co-channel and adjacent channel operation (elimination of carrier whistle). Although these advantages are small in number, they are large in their importance to commercial and military communications.

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Harvey Slovik Editor

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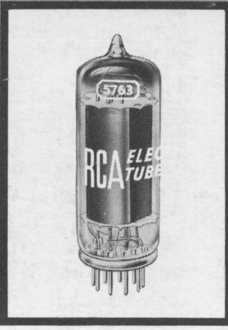


THE WEEKEND SPECIAL

A Complete, Portable 40-Meter CW Station

By Lee Aurick, W2QEX

RCA Electron Tube Division, Harrison, N. J.

For many hams, a weekend jaunt or a vacation trip with the family means being off the air for the duration. The author, to whom such trips meant a sacrifice of practically the only time available for work at the home station, undertook to solve the problem by the design of a portable 40-meter cw station which would fit unobtrusively into the family luggage and yet provide a high degree of operating convenience and efficiency.

In planning the station, the author considered the following features essential:

(1) The entire station should fit in a portable typewriter case.

(2) The transmitter should have a vfo and provision for oscillator "spotting."

(3) To assure freedom from objectionable frequency variations during operation under marginal conditions, the vfo should have a regulated plate-voltage supply.

(4) The final should load properly when connected to a 72-ohm load (pre-cut 40-meter doublet with coaxial feed).

(5) The transmitter should include a single tuning and keying monitor.

(6) Changeover from "transmit" to "receive" should be a one-switch operation.

(7) The receiver should provide good bandspread for the 40-meter band.

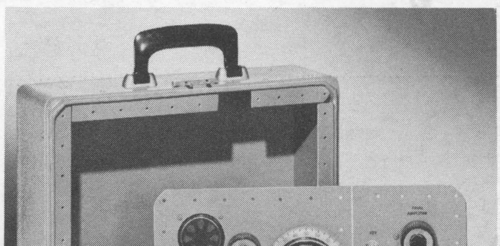
(8) The receiver should deliver sufficient af-output power to operate a small built-in speaker.

(9) The entire station should use proved circuits and cost less than $100.

The rig shown in the accompanying photographs and circuit diagrams fulfills all these design requirements with one minor exception—the 66-foot doublet antenna and its 50-foot 72-ohm feeder, of course, do not fit easily into the portable typewriter case. They have to be carried elsewhere in the family luggage.

Circuit Details

The limitations on the size and cost of the station dictated the use of a two-tube regenerative receiver. The one which seemed to offer the most advantages and best met the other requirements was the "Novice Special" de-



Four brackets made of ¾-inch aluminum angle are utilized. One supports the power-supply "deck." The others, mounted on three sides of a portable typewriter case, support the front panels of W2QEX's 40-meter cw station.

scribed by Mix in QST for June, 1956. With minor modifications (a slight change in the method of tuning, and the use of a permanently mounted 40-meter coil instead of plug-in coils), this receiver was adopted. The power supply described by Mix for use with the receiver was also adopted, and used for the transmitter as well as the receiver.

As shown in Figure 1, RCA-6AQ5-A's are used in both the detector and af-amplifier stages. The detector provides smooth and stable regeneration, and the tuning arrangement spreads the 40-meter band over 70 divisions (10 to 80) on the tuning dial. The af-amplifier stage delivers sufficient output to operate the built-in speaker on practically every station that can be heard.

L_1 is a 9-turn length of B & W Type 3015 Miniductor, tapped at 2 turns (terminal 2), 4¼ turns (terminal 3), and 5 turns (terminal 4). C_3 is the "bandset" capacitor which, with the fixed mica padder capacitor, C_2, determines the tuning range. C_1 is the "bandspread" capacitor. When C_3 is properly set, C_1 covers a range extending approximately 40 kilocycles beyond each edge of the 40-meter band. R_2 is the regeneration control, and S_1 is the speaker-headphone selector switch.

Transmitter

The transmitter circuit is shown in Figure 2. The variable-frequency-oscillator stage uses an RCA-6AU6 in a Clapp circuit with electron-coupled output. The oscillator is tuned by the "bandset" capacitors C_{13} and C_{14}, and the "bandspread" capacitor C_{15}. The combination of C_{20} and L_4 in the plate circuit of the 6AU6 is tuned to the center of the cw portion of the 40-meter band, and covers this portion of the band without retuning.

An RCA-OA2 voltage-regulator tube is used to provide constant voltage for grid No. 2 of the 6AU6, which is the "plate" of the oscillator.

Because the RCA-5763 is a single-ended type and is operated as a "straight-through" rf amplifier, the output stage is neutralized to minimize any tendency to self-oscillation. The neutralizing circuit is extremely simple and requires no adjustments. All that is necessary is the connection shown in Figure 2 between the bottom of L_4 and pin 2 of the 5763 socket. The capacitance between pin 2, which has no internal connection, and the plate pin (pin 1) provides a feedback voltage of the proper phase and amplitude for neutralization.

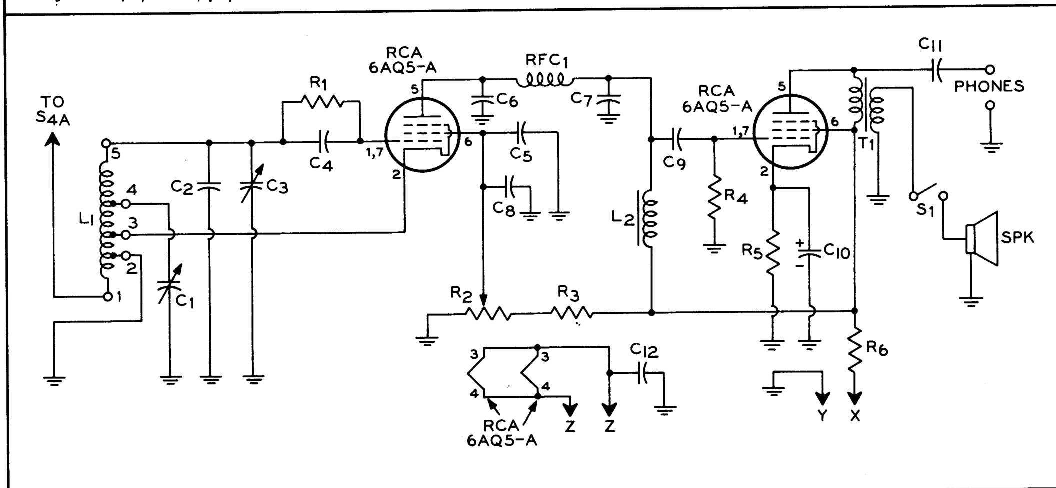
The output-tank circuit of the amplifier (C_{24}, L_5, and C_{25}) is a simplified pi network designed to provide proper loading for the 5763 when connected to the 72-ohm feeder for the 40-meter doublet antenna.

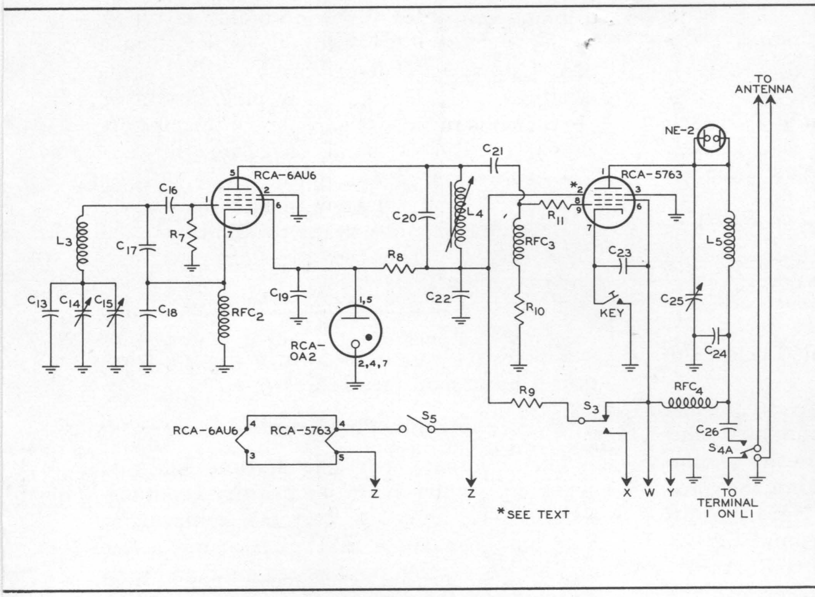
Switch S_3 is a momentary-contact push-button type which, when depressed, applies plate and screen-grid voltage to the 6AU6, permitting the oscillator to be "spotted" to the received frequency.

An NE-2, 1/25-watt neon lamp, is used as

Figure 1: Circuit of the two-tube regenerative receiver.

C_1—100 $\mu\mu$f, variable (Hammerlund type Mc-100M or equivalent)
C_2—330 $\mu\mu$f, mica
C_3—7-45 $\mu\mu$f, ceramic trimmer
C_4—100 $\mu\mu$f, mica
C_5, C_6, C_7, C_{12}—0.001 μf, disc ceramic
C_8—1 μf, 400 v, paper
C_9—0.02 μf, 400 v, paper
C_{10}—10 μf, 25 v, electrolytic
C_{11}—1 μf, 400 v, paper
L_1—see text
L_2—35 Henries @ 15 ma (Thordarson type 20C51 or equivalent)
R_1—6.8 megohms, 0.5 w
R_2—50,000 ohms, 4 w, w.w. (Mallory type M50 MPK or equivalent)
R_3—150,000 ohms, 1 w
R_4—50,000 ohms, ½ w
R_5—330 ohms, 1 w
R_6—1000 ohms, 5 w
RFC1—2.5 MH
S_1—S.P.S.T., toggle switch
SPKR—RCA type 222S1
T_1—pri. 5000 ohms, sec. 3.5 ohms, 5 w (Thordarson type 24S51 or equivalent)





C_{13}—25 $\mu\mu$f mica
C_{14}—4.5-25 $\mu\mu$f, ceramic trimmer
C_{15}—10 $\mu\mu$f, variable (Cardwell type PL-6000 or equivalent)
C_{16}, C_{20}, C_{21}, C_{22}—100 $\mu\mu$f, mica
C_{17}, C_{18}—270 $\mu\mu$f, mica
C_{19}, C_{23}—0.001 μf, ceramic
C_{24}—150 $\mu\mu$f, mica
C_{25}—35 $\mu\mu$f, variable (Hammerlund type MC-35S or equivalent)
C_{26}—0.03 μf, ceramic
L_3,L_4, L_5—see text
Neon Lamp—type NE-2
R_7—22,000 ohms, 0.5
R_8—5,600 ohms, 2 w
R_9—6800 ohms, w.w., 5 w
R_{10}—18000 ohms, 0.5 w
R_{11}—200 ohms, 0.5 w
RFC_2—0.5 millihenries
$RFC_{3,4}$—2.5 millihenries
S_3—S.P.D.T., push button, momentary-contact switch
S_4—D.P.D.T., toggle switch
S_5—S.P.S.T., rotary switch

Figure 2: Transmitter circuit.

a tuning and keying monitor. The leads of this lamp are soldered to the stator of C_{25}. The lamp is mounted so that its tip protrudes through a small hole in the front panel directly below the tuning knob for C_{25}.

The oscillator tank coil L_3 is a 37-turn length of B & W type 3012 Miniductor. L_4 is 23 turns of No. 20 enameled wire wound on a CTC type (LS-4) ½-inch diameter iron-core form. L_5 is 28 turns of No. 20 enameled wire, 1¼ inches in diameter and 1½ inches long. L_5 may also be a B & W type MC, 40-meter coil with the link winding and 5-prong plug-in base removed, mounted on feed-through insulators.

Switch S_4 is the transmit-receive switch, and applies high voltage and the antenna lead-in to either the transmitter or receiver.

Switch S_5 is used to remove heater voltage from the transmitter tubes during long stand-by periods.

Assembling the Complete Station

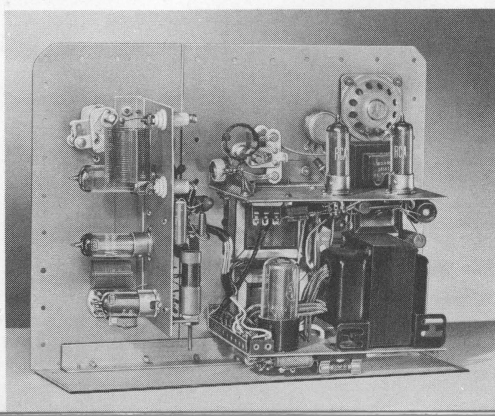
The entire station was installed in a portable typewriter case approximately 12¾ inches square and 4¼ inches deep.

To simplify construction and maintenance, the transmitter, receiver, and common power supply were built on separate "decks" and the front panel was divided into two "operating areas," which can be individually removed. The left-hand area contains the power supply (the heaviest item) and the receiver; the right-hand area the transmitter. The panels and "decks" occupy a space about 9¼ inches high. The 3¼-inch-high compartment at the bottom of the case is used to store the line-cord, key, and station log.

The front panels are supported by brackets made of ¾-inch aluminum angle mounted on three sides of the case. These brackets are recessed about ⅛ inch so that the front panels are flush with the edges of the case. For additional rigidity, the three "decks" were made 4⅛ inches deep so that their rear edges rest against the rear of the case. The "decks" containing the receiver and power supply are 6⅜ inches wide, and the transmitter "deck" is 6⅝ inches wide. A small bracket supports the power-supply "deck."

To minimize coupling between the oscillator-grid and amplifier-plate coils, these coils are mounted at opposite ends of the transmitter "deck," with their axes at right angles.

The oscillator-grid and amplifier-plate coils are mounted at opposite ends of the transmitter "deck" with their axes at right angles. The oscillator-plate coil is mounted below the "deck."



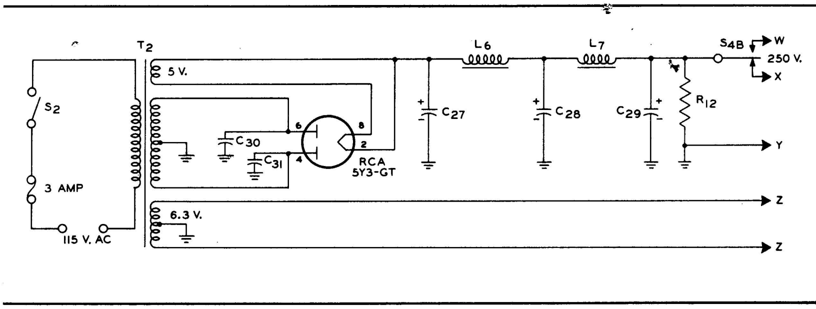


Figure 3: Power-supply circuit.

C_{27}, C_{28}, C_{29}—16 μf, 450 v, electrolytic
C_{30}, C_{31}—0.001 μf, disc ceramic
L_6, L_7—16 Henries @ 50 ma (Stancor type C-1003 or equivalent)
R_{12}—50,000 ohms, 5 w
S_2—S.P.S.T., toggle switch
T_2—500 v C.T. @ 70 ma., 5.0 v @ 2.0 amp, 6.3 v @ 2.5 amp (Stancor type PM-8403 or equivalent)
Fuse—3 amp

The oscillator-plate coil is mounted below the "deck."

To assure mechanical stability in the oscillator circuit, L_3 is rigidly mounted and connected by a very short lead to the oscillator-tuning capacitor C_{15}. In addition, the rotor of C_{15} is grounded through a rigid No. 10 copper-wire connection to a ground lug on the "deck" directly below the capacitor.

The only critical point in the receiver is the position of the feedback tap (terminal 2) on L_1. If the receiver does not regenerate smoothly, try moving this tap 1/4 inch at a time. It will be found easier to solder connections to this coil if the turns on both sides of the tap points are first depressed.

The power supply, shown in Figure 3, requires no special mention.

Station Performance

This 40-meter portable station has met every one of the operating requirements initially established. The best DX achieved to date has been about 500 miles, using a low and hastily erected doublet antenna, and with 225 volts on the plate of the 5763. Thorough workouts, under a variety of operating conditions during the 1958 ARRL Field Day, summer vacations in the country, and several weekend trips, have convinced one ham family that amateur radio and family travel are not necessarily incompatible.

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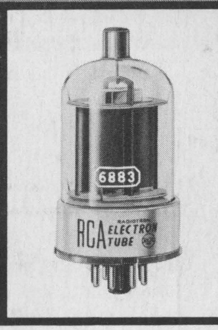
Harvey Slovik, Editor

HAM TIPS



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5-BAND MOBILE TRANSMITTER

A 50-Watt Rig for Phone and CW Operation

By George D. Hanchett, W2YM

RCA Electron Tube Division, Harrison. N. J.

> Did you know that a reciprocal agreement makes it possible for United States radio amateurs to operate their ham equipment in Canada—and vice versa?* This agreement has probably inspired many hams—as it did W2YM—to include portable or mobile operation in their cross-the-border vacation plans.

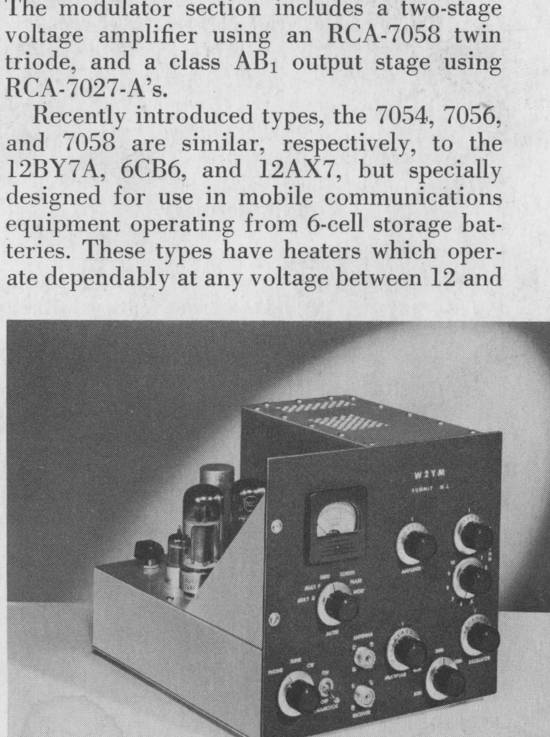
The 50-watt transmitter described in this article started out to be a simple single-band mobile job for use on a Canadian fishing trip. As the design progressed, however, more and more features seemed necessary or desirable, and it finally emerged as a five-band, crystal-controlled rig for phone and CW operation on 80, 40, 20, 15, and 10 meters.

This transmitter features a bandswitching system which automatically provides the proper drive for the final on each band, and remote control of practically all operating functions from a dashboard control unit. It was designed to operate from a 12.6-volt car battery and 450-volt, 250-milliampere dynamotor. With minor modifications, as described later, the rig can be operated from dynamotors or other plate-supply sources delivering as little as 300 volts.

Figure 3 shows the circuit of the transmitter. For its structural features and layout, see the photographs on pages 3 and 4, as well as the picture below.

The rf section consists of a crystal-oscillator stage using an RCA-7056, a buffer-frequency-multiplier stage using an RCA-7054, and a final stage using an RCA-6883. The modulator section includes a two-stage voltage amplifier using an RCA-7058 twin triode, and a class AB_1 output stage using RCA-7027-A's.

Recently introduced types, the 7054, 7056, and 7058 are similar, respectively, to the 12BY7A, 6CB6, and 12AX7, but specially designed for use in mobile communications equipment operating from 6-cell storage batteries. These types have heaters which operate dependably at any voltage between 12 and



*See FCC Commission Rules and Regulations, Part 12—Amateur Radio Service, Appendix 4.

15 volts and can withstand momentary excursions from 11 to 16 volts.

The 6883 is the 12.6-volt equivalent of the 6146.

The 7027-A's used in the output stage of the modulator are RCA beam power tubes designed especially for use in high-fidelity applications. They have characteristics similar to those of the 6L6-GB but with substantially higher plate-voltage and grid-No. 2 voltage ratings (600 volts and 500 volts, respectively) and higher power-output capabilities in class AB_1 service. They were selected for use in this transmitter because their high plate- and grid-No. 2-voltage ratings permitted them to be operated directly from the 450-volt supply, and because they easily provide the audio power required for 100% plate and grid-No. 2 modulation of the 6883.

Keying for CW operation is accomplished in the cathode circuit of the final amplifier.

The power-supply unit, shown schematically in Figure 1, contains the dynamotor, a filter capacitor for the 450-volt line, the relays used to open and close the main battery and dynamotor-input circuits, and fuses for these circuits.

The dashboard control unit, shown schematically in Figure 2, contains the heater-and plate-power on-off switches, a crystal-selector switch, the receiver-B+ switch and relay, and a switch used to transfer the car speaker from the broadcast receiver to the communications receiver and vice versa. It also contains a heater-circuit fuse, pilot lamps showing the condition of the heater and plate-supply circuits, and the input connectors for the microphone and key.

Circuit Details

The transmitter is designed to use 3.5-Mc crystals for 80 meters, 3.5- or 7-Mc crystals for 40 meters, and 7-Mc crystals for all other bands. In the 80-, 40-, 20-, and 15-meter positions of the bandswitch (S_1), the oscillator output is untuned. In the 10-meter position of the bandswitch, the oscillator output is tuned to twice the crystal frequency—that is, to 14 Mc—by C_6 and L_1. The second stage, therefore, operates as an amplifier on 80 meters, as either an amplifier or a doubler on 40 meters (depending on the crystal used), as a doubler on 20 and 10 meters, and as a tripler on 15 meters.

L_2, the grid-circuit coil for the 6883, is a 2-inch length (32 turns per inch) of B & W Type 3008 Miniductor, tapped as shown in Figure 3, and is tuned by C_{15}. In the 80-meter position of the bandswitch, the total capacitance across L_2 is increased by the addition of C_{13}. The 6883 is neutralized by a bridge circuit consisting of C_{14}, RFC_4, and C_{16} to assure good stability of the 6883 on all bands.

The plate tank for the 6883 is a conventional pi-network type using two tapped coils. L_4, the coil for the 20-, 15-, and 10-meter bands, is a 10-turn winding of No. 10 enameled copper wire, having an inside diameter of 1 inch and an overall length of 1¾ inches. L_5, which is in series with L_4 for the 80- and 40-meter bands, is an 18-turn section of B & W Type 3018 inductor. Positions of the taps on L_4 and L_5 are given in Figure 3.

L_3 is a parasitic-suppressor choke consisting of 6 turns of plastic-insulated hookup wire, about ¼ inch in diameter, and is installed directly between the plate-cap connection of the 6883 and the plate end of RFC_5.

The adjustable loading-capacitance at the output end of the pi network consists of a 140-µµf variable capacitor (C_{26}), and a group of fixed capacitors controlled by the bandswitch and the "Coarse Loading" switch S_3. A 500-µµf capacitor (C_{25}) is connected in parallel with C_{26} in the 80-meter position of

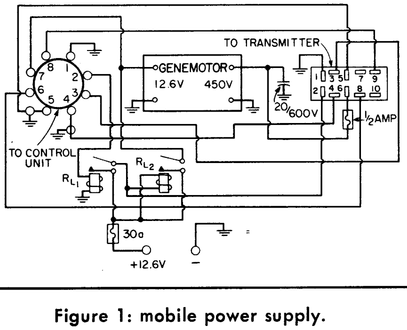


Figure 1: mobile power supply.

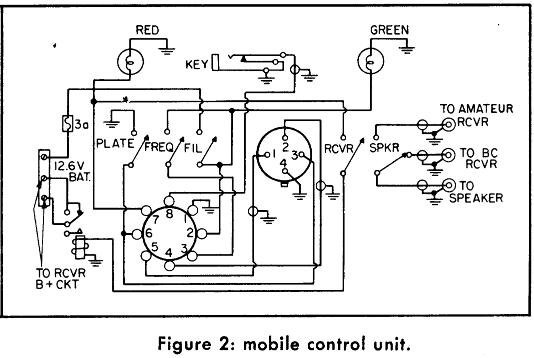
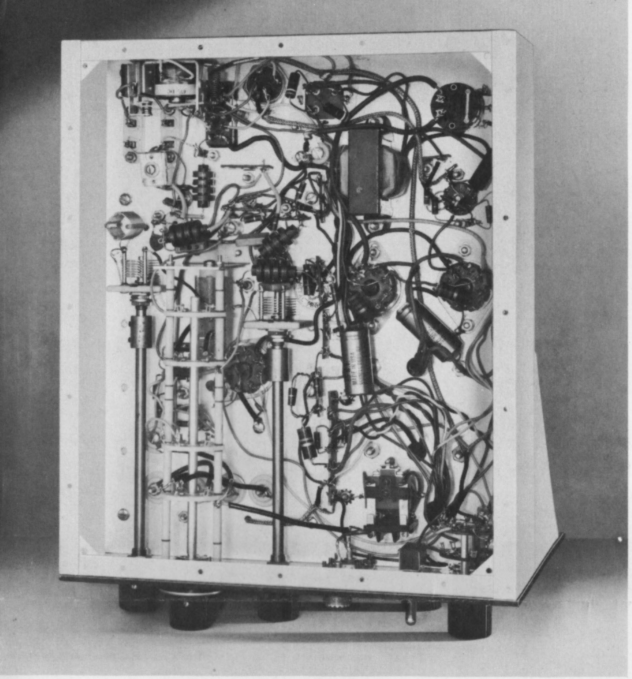


Figure 2: mobile control unit.



The microphone-cable shield is not grounded anywhere except at the socket for the 7058.

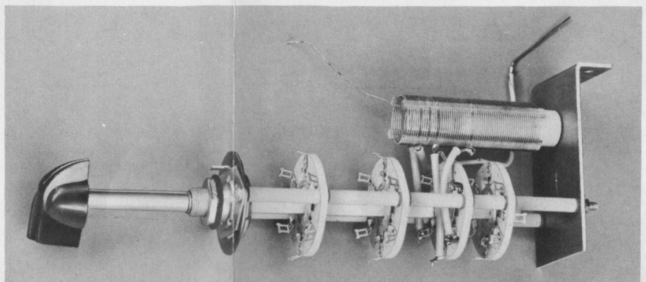
the bandswitch, and the nine 150-$\mu\mu$f capacitors (C_{27} through C_{35}) are successively added in parallel with C_{26} when S_3 is rotated counterclockwise.

The modest and noncritical drive requirements of the 6883 permitted the use of a simple step-type drive control ganged with the bandswitch. As shown in Figure 3, section S_{1b} of the bandswitch is connected to taps on a resistive voltage-divider network across the 450-volt supply circuit, and automatically adjusts the grid-No. 2 voltage of the 7054 buffer/frequency multiplier so as to provide the proper drive for the 6883 on each band.

The voltage-divider network shown at the input to the modulator circuit in Figure 3 was designed for use with the transistorized microphone described in the September, 1956, issue of HAM TIPS. (Please note that the three-wire cable shown in this previous HAM TIPS article has been changed to a four-conductor cable. This change was made so that the ground connection for audio can be made right at the 7058 socket, thereby eliminating any possibility of ground-current pickup.) Alternate input connections for use with a carbon microphone are also shown in Figure 3 (see inset).

To minimize the drain on the 450-volt supply under no-signal conditions, the 7027-A's are operated with somewhat higher bias than that required for true class AB_1 operation. Although this method of operation might cause severe distortion of a steady-tone modulating signal, it has relatively little effect on the quality of speech modulation

Close-up view of the bandswitch shows detail of 6883 grid coil.



because of the very low average power of speech signals.

Changeover from phone to CW operation is accomplished by means of the "PHONE-TUNE-CW" switch (S_6). In its "TUNE" position, this switch removes grid-No. 2 voltage from the 6883 and plate and grid-No. 2 voltage from the 7027-A's, so that the oscillator and buffer/multiplier stages can be tuned without danger of damage to the final amplifier.

The meter and associated switch (S_2) are used to measure: the 7054 grid-No. 1 and plate current; the 6883 grid-No. 1, grid-No. 2, and plate currents; and the combined plate and screen currents of the 7027-A's.

Switch S_5 is mounted on the modulator gain-control potentiometer (R_{29}), and may be used to remove heater voltage from the modulator tubes when long periods of CW operation are contemplated.

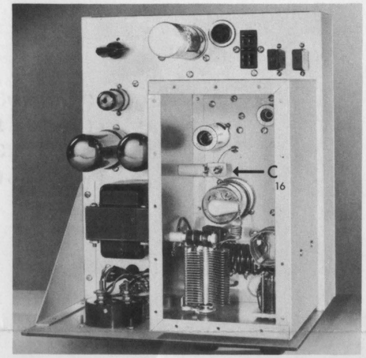
Mechanical Features

The transmitter was built on a 10-inch by 12-inch by 3-inch aluminum chassis and a 10-inch by 10-inch panel. The tubes and output network of the rf section are enclosed in a 5-inch by 7-inch by 9-inch aluminum utility box.

The bandswitch (S_1), shown on page 3, was assembled from Centralab steatite wafers and spacers to permit each section to be located as near as possible to the associated stage or components. L_2, the grid coil for the final stage, is mounted on a small standoff insulator on the bandswitch support bracket.

The taps on L_2 were made by cutting the coil stock ½ turn beyond the desired tap point, bending back the cut ends ½ turn, and twisting them together. The twisted leads were then soldered to make them as stiff as possible. (This procedure is repeated for each tap, making sure that the removed turns are not counted.)

The crystal-selector switch and relay permit change of the operating frequencies directly at the operating position. If the crystals are selected so that the resulting output frequencies are separated by not more than about 0.05%, it will not be necessary to readjust the transmitter when shifting from one crystal to the other.



Looking at the top of W2YM's five-band mobile transmitter. Note neutralizing capacitor C_{16} mounted on small bracket and standoff insulation between 6883 and 7054.

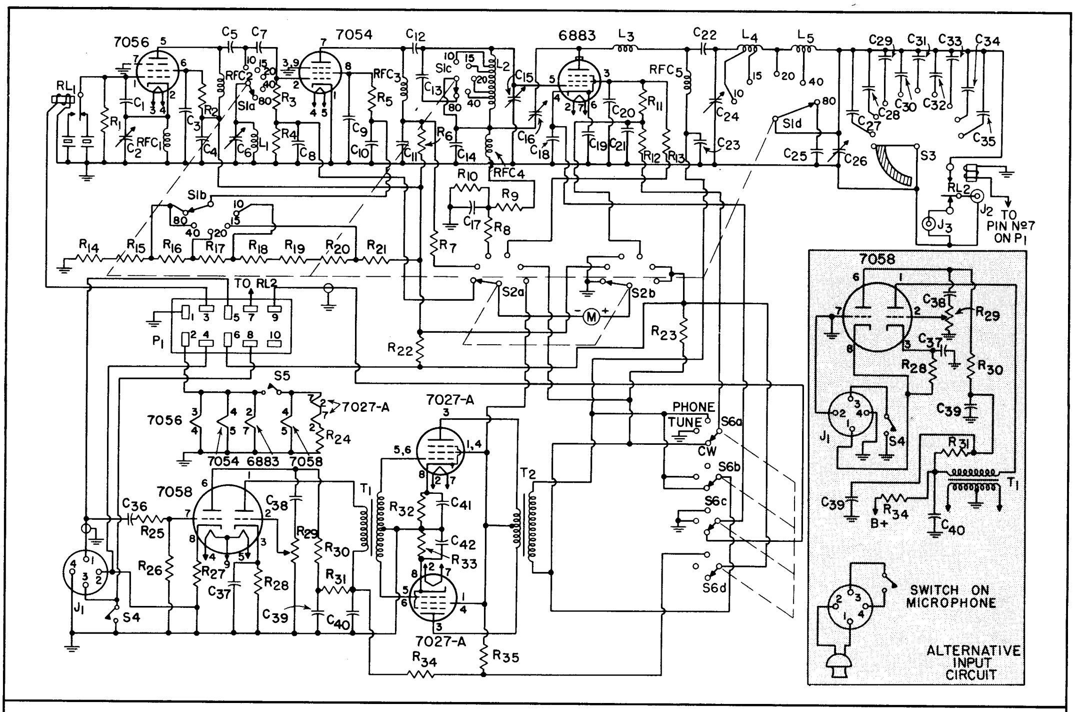
The "DYNAMOTOR ON-OFF" switch on the transmitter panel and a local microphone connector (J_1) permit the transmitter to be operated directly at its location in the trunk compartment.

Modifications

If the transmitter is to be operated from a plate supply delivering less than 450 volts, it will be necessary to change the values of the series resistor in the plate-supply circuit for the oscillator and buffer/doubler stages (R_{22}), the grid-No. 2 resistor for the 6883 (R_{12}), and the cathode resistors for the 7027-A's (R_{32} and R_{33}). The proper values for these resistors for various plate-supply voltages are shown in Figure 3.

This transmitter has been in use for about one year and has produced very rewarding signal reports as well as some excellent DX. The reports indicate that the quality of the phone signals provided by the transistorized microphone is greatly superior to that of most mobile transmitters using conventional carbon microphones.

Figure 3: Schematic diagram and parts list of the five-band mobile transmitter. See inset for suggested speech amplifier circuit for use with carbon microphone.



C_1—22 $\mu\mu$f, mica
C_2—80-400 $\mu\mu$f, compression mica
C_3, C_4, C_8, C_9, C_{10}, C_{11}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}—.001 μf, Disc Ceramic, 600 v
C_5, C_7, C_{12}, C_{18}, C_{19}, C_{20}, C_{21}—.002 μf, mica
C_6, C_{15}—50 $\mu\mu$f, variable (Hammarlund HF-50 or equiv.)
C_{13}—47 $\mu\mu$f, NPO Ceramicon or equiv.
C_{14}—.001 μf (Erie Feed-Thru Ceramicon or equiv.)
C_{16}—3.5-12 $\mu\mu$f, tubular trimmer (Centralab or equiv.)
C_{22}—.002 μf, mica, 1500 v (Aerovox #1467LS or equiv.)
C_{23}—.001 μf, 1500 v, disc ceramic
C_{24}—325 $\mu\mu$f, variable (Hammarlund MC-325-M or equiv.)
C_{25}—500 $\mu\mu$f, mica
C_{26}—140 $\mu\mu$f, variable (Hammarlund HF-140 or equiv.)
C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}, C_{33}, C_{34}, C_{35}—150 $\mu\mu$f, mica
C_{36}—.01 μf, 400 v, paper
C_{37}—10 μf/25 v, electrolytic
C_{38}—.005 μf, 400 v, paper
C_{39}, C_{40}—20 μf/450 v, dual electrolytic
C_{41}, C_{42}—50 $\mu\mu$f/50 v, electrolytic
J_1—Amphenol #91-PC4F or equiv.
J_2—antenna connector, coax.
J_3—receiver-antenna connector, coax.
L_1—12 turns B & W #3007
L_2—57 total turns B & W #3008, tapped at 5½, 8¼, 11½, and 26½ turns from grid end
L_3—6 turns hook-up wire, ¼" diameter
L_4—11 turns #10 enameled wire, 1" inside diameter, 1¾" long, tapped at 5½ and 8½ turns from plate end
L_5—18 turns B & W #3018, tapped at 8 turns from L_4
M—0-3 ma, 2"
P_1—Jones type 300 (P310AB) or equiv.
R_1—100,000 ohms/½ watt
R_2—33,000 ohms/½ watt
R_3—68,000 ohms/½ watt
R_4, R_5, R_6, R_7, R_8, R_{10}, R_{13}, R_{27}, R_{28}—1,000 ohms/½ watt
R_9—27,000 ohms/1 watt
R_{11}—110 ohms/1 watt (made by connecting two 220-ohm/½-watt resistors in parallel)
R_{12}—12,000 ohms (300 v), 18,000 ohms (350 v), 22,000 ohms (400 v), 24,000 ohms (450 v)—2 watts
R_{14}, R_{15}, R_{16}, R_{17}, R_{18}, R_{19}, R_{20}—5,100 ohms/½ watt
R_{21}—12,000 ohms/1 watt
R_{22}—none (300 v), 1,200 ohms (350 v), 3,300 ohms (400 v), 4,700 ohms (450 v)—1 watt
R_{23}, R_{35}—10 ohms/½ watt
R_{24}—1 ohm/½ watt
R_{25}, R_{26}, R_{30}—47,000 ohms/½ watt
R_{29}—½ megohm/½ watt, volume control with switch (S_5)
R_{31}, R_{34}—3,900 ohms/½ watt
R_{32}, R_{33}—860 ohms (300 v), 1,000 ohms (350 v), 1,200 ohms (400 v), 1,500 ohms (450 v)—2 watts
RFC_1, RFC_2, RFC_4—2.5 mh, National R-50 or equiv.
RFC_3—1.0 mh, National R-50 or equiv.
RFC_5—1.0 mh, National R-300 ST or equiv.
RL_1, RL_2—12-volt dc relays, SPDT
S_1—4 pole, 5 position (made from Centralab PA-305 index and four PA-17 steatite sections)
S_2—2 pole, 6 position (Centralab PA-2003 or equiv.)
S_3—single pole, 10 position, progressively opening (Centralab PA-2052 or equiv.)
S_4—SPST, toggle
S_5—SPST (see R_{29})
S_6—4 pole, 3 position (Centralab PA-2011 or equiv.)
T_1—3:1 single plate to push-pull grids (Thordarson 20A19 or equiv.)
T_2—10,000 ohms P to P to RF load (Thordarson 21M67 or equiv.)

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Harvey Slovik, Editor

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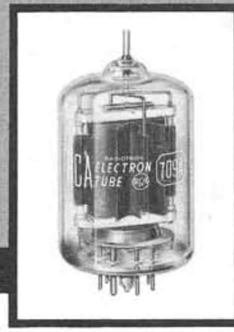


FOR SSB SERVICE:

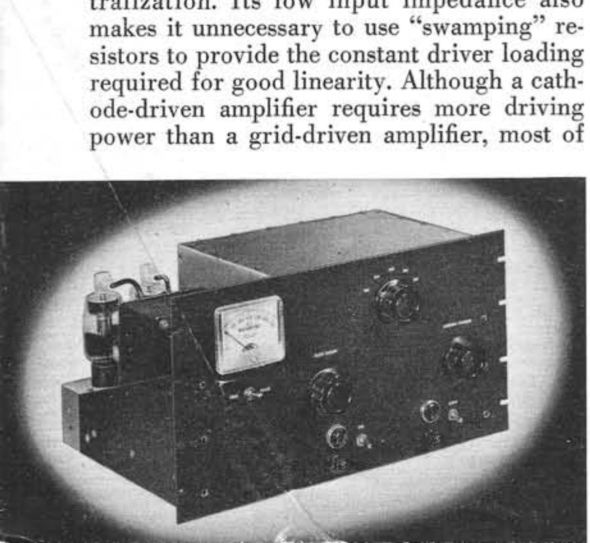
Cathode-Driven Linear Amplifier Using RCA-7094 Beam Power Tube

By Claude E. Doner, W3FAL

RCA Electron Tube Division, Lancaster, Pa.

This article features an extremely stable, five-band, cathode-driven linear amplifier for single-sideband service. Employing a single RCA-7094 beam power tube, the amplifier provides bandswitched operation on 80-, 40-, 20-, 15-, and 10-meter bands and is easily constructed and adjusted. Under the conditions described by W3FAL, it delivers a peak envelope power of approximately 200 watts.

The high power gain, high efficiency, and low distortion necessary in a linear amplifier for single-sideband service can be provided most economically by a high-mu triode in a cathode-drive circuit. Because of its low input impedance, a cathode-driven amplifier does not require a tuned input circuit. And, because of the plate-cathode shielding provided by the grid, it usually does not require neutralization. Its low input impedance also makes it unnecessary to use "swamping" resistors to provide the constant driver loading required for good linearity. Although a cathode-driven amplifier requires more driving power than a grid-driven amplifier, most of the driving power appears as useful power in the output circuit, so that high overall efficiencies can be achieved. Additional economies can be achieved by the use of a triode which can be operated as a zero-bias class B amplifier.



Beam power tubes or tetrodes which can be operated as high-mu triodes make excellent linear amplifiers. They are especially useful in cathode-drive circuits, because of the excellent shielding provided by the two grids.

The RCA-7094 beam power tube has extremely good triode characteristics. It is particularly useful in cathode-drive service (1) because of its low plate-cathode capacitance and high perveance and (2) because it has an indirectly heated cathode and, therefore, does not require the use of filament chokes. As a class B linear amplifier in single-sideband service, a triode-connected 7094 with forced-air cooling can handle a peak-envelope-power input of 350 watts with only 1750 volts on the plate and zero bias on grids No. 1 and No. 2.

The circuit of the amplifier and power supply is shown in Figure 1. For illustrations of

the layout and mechanical construction, see the photographs on pages 1, 3, and 4.

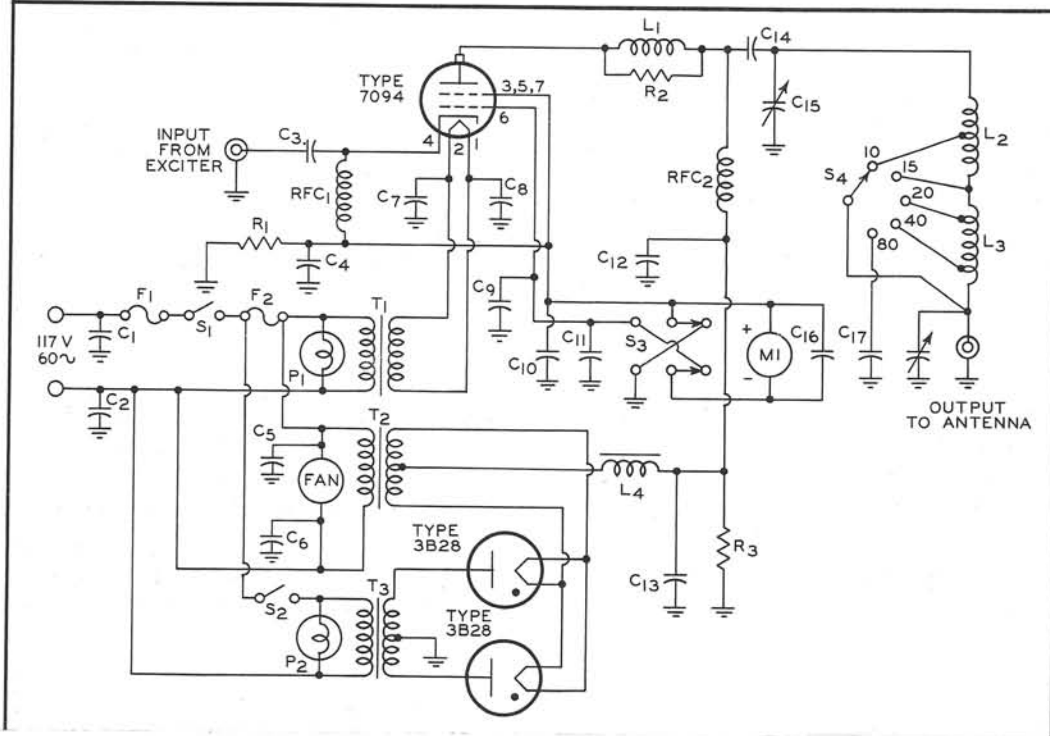
Note that although grids No. 1 and No. 2 of the 7094 are connected in parallel for rf through C_4, C_9, C_{10}, and C_{11}, the dc return for the input circuit is connected to grid No. 2. The grids are not connected in parallel for dc except when the meter switch (S_3) is in the plate-current position. This arrangement permits a single milliammeter connected in the ground side of the circuit to be used to measure either grid current or plate current without the hazard involved in switching the meter in and out of the high-voltage lead. It also minimizes the possibility of improper adjustments which would exist if the meter were used to measure only total cathode current.

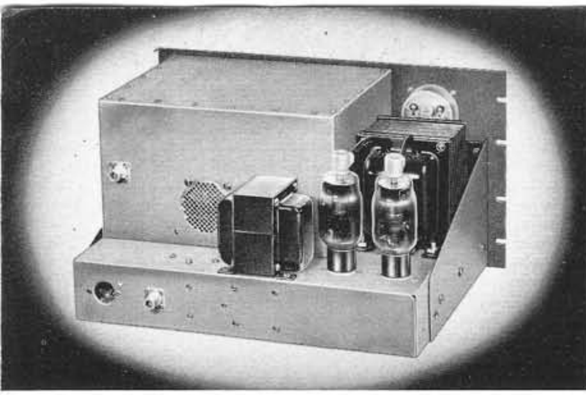
A pi-network type, the output tank uses two tapped coils and a shorting-type bandswitching arrangement. L_2, the coil for the 10- and 15-meter bands, is wound of $\frac{3}{16}$-inch copper tubing and has 9 turns spaced $\frac{1}{4}$ inch apart and an inside diameter of two inches. L_3, the loading inductance for the 20-, 40-, and 80-meter bands, consists of 23 turns of B & W type 3095-1 coil stock.

The positions of the taps were chosen to provide an operating Q of approximately 12 on all bands for a 50-ohm load. The 10-meter tap is approximately four turns from the tube end of L_2 and should be adjusted so that the plate-tuning capacitor (C_{15}) is almost fully open when the circuit is resonant at the high-frequency end of the 10-meter band. The 15-meter tap is connected to the junction between the two coils. The 20- and 40-meter taps are

Figure 1: Schematic diagram and parts list of W3FAL's linear amplifier and power supply.

C_1, C_2, C_3, C_4, C_7, C_8, C_9, C_{16}—0.01 μf, 600 v, disc ceramic
C_5, C_6, C_{10}, C_{11}—1000 $\mu\mu$f, 500 v, ceramic feedthrough
C_{12}—.0047 μf, 3000 v, disc ceramic
C_{13}—8 μf, 2000 v, oil filled
C_{14}—1000 $\mu\mu$f, 5000 v, ceramic standoff
C_{15}—11 to 100 $\mu\mu$f, variable (E. F. Johnson 100E30 or equiv.)
C_{17}—500 $\mu\mu$f, 5000 v, ceramic standoff
C_{18}—19 to 488 $\mu\mu$f, variable (E. F. Johnson 500E20 or equiv.)
F_1—5 amp fuse, 3AG type
F_2—1 amp "slo blo" fuse, 3AG type
L_1—1 turn, ½" ID (see text)
L_2—9 turns, 2" ID (see text)
L_3—23 turns from a Barker & Williamson 3905-1 coil or equiv.
L_4—8 henry, 250 ma filter choke (Thordarson 20C56 or equiv.)
M_1—0 to 300 ma meter (Triplett 327-PL or equiv.)
P_1, P_2—115 v pilot lamp assemblies
RFC_1—2.5 mh, 300 ma (National R300U or equiv.)
RFC_2—.225 mh, 800 ma (National R175A or equiv.)
R_1—1000 ohms, 2 watts, carbon
R_2—(3) 100 ohms, 2 watts, carbon (see text)
R_3—(2) 100,000 ohms, 50 watts, wire wound (connected in parallel)
S_1, S_2—SPST toggle switch
S_3—DPDT toggle switch
S_4—5 tap rotary switch, ceramic (Ohmite 111 or equiv.)
T_1—6.3 v, 4 amp filament transformer (Stancor P4019 or equiv.)
T_2—2.5 v, 10 amp filament transformer (Thordarson 21F02 or equiv.)
T_3—2065-0-2065 v ac, 1750 v dc at 200 ma plate transformer (Stancor PT8315 or equiv.)
Fan—small tube cooling motor and fan, 115 v ac





Rear view of the cathode-driven linear amplifier shows the rf enclosure and power supply components.

19 and 10 turns, respectively, from the output end of L_3. In the 80-meter position of the bandswitch, a 500-$\mu\mu$f fixed capacitor (C_{17}) is connected in parallel with the loading capacitor (C_{18}).

The meter is a single-scale, 0-300-milliampere type. A lower range meter and external shunt were not considered necessary because the normal grid current (80 milliamperes) and plate current (200 milliamperes) can easily be read on the same scale. The 1000-ohm resistor (R_1), connected between the positive side of the meter and ground, prevents high voltage from appearing at the cathode in the event of switch failure.

The power supply is a conventional full-wave type with choke-input filter. Type 3B28 gas rectifier tubes were used instead of 866-A's to eliminate the "hash" produced by the mercury-vapor types and to permit the amplifier to be operated on its side during tests and initial measurements. However, if you prefer, 866-A's may be used in place of the 3B28's without any changes in circuit values—provided the amplifier is always kept in a position such that the tubes are vertical.

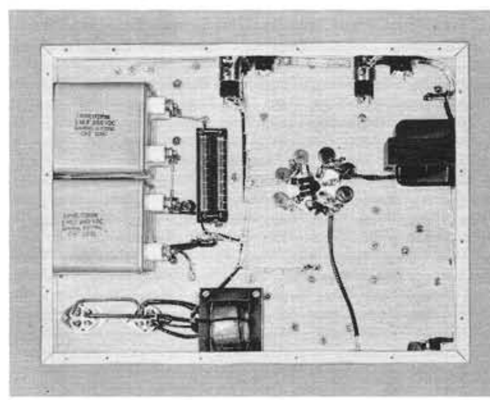
The plate-power switch (S_2) is connected in series with the heater/filament-power switch (S_1) in such a manner that power cannot be applied to the rectifier plates until the filaments of the 3B28's and the heater of the 7094 have been energized. If 866-A mercury-vapor rectifiers are used, it will be necessary to delay application of plate power for at least 30 seconds after filament power has been turned on.

Construction

Because of the simplicity of the circuit, it was possible to construct the amplifier and power supply on a 12- by 17- by 3-inch chassis and a 10½- by 19-inch rack panel. The chassis is bolted directly to the panel and reinforced with 6½- by 11-inch chassis mounting brackets. The 7094 and plate-tank components are enclosed in a 7- by 12- by 9½-inch shield made of 18-gauge sheet aluminum. The front of this shield is mounted flush against the rack panel, and both are drilled for the shafts of the plate-tuning and loading capacitors and the bandswitch. Half-inch-wide flanges on the top and bottom of the shield provide good rf contact to the chassis and the perforated aluminum cover plate.

The small fan mounted on the back wall of the enclosure provides forced-air cooling for the 7094. Serving as the air inlet is a circular area of closely-spaced ⅛-inch holes, 3 inches in diameter. The holes are drilled in the wall behind the fan.

To minimize rf losses, all connections between the plate-tank circuit components, the bandswitch, and the 7094 are made of ¼-inch-wide copper strap. A 4-inch length of RG/8U coaxial cable is used for the connection between the loading capacitor and the output coaxial connector.



Looking at the underside of the amplifier chassis.

The parasitic suppressor in the plate lead (L_1) is a single turn of ⅜-inch-wide copper strap, ½ inch in diameter, shunted by three 100-ohm, 2-watt composition resistors connected in parallel.

The bypass capacitors for the meter (C_{10}, C_{11}, and C_{16}) and fan (C_5 and C_6) are feed-through types. They are installed at the points where the leads to these components pass through the chassis.

Because a single 8-μf capacitor (C_{13}) small enough to fit underneath the chassis was not available, four 2-μf capacitors were used (see the photograph of the chassis underside).

Tuning and Operating Adjustments

The amplifier requires a single-sideband exciter that can deliver a peak envelope power of approximately 15 watts. To tune the ampli-

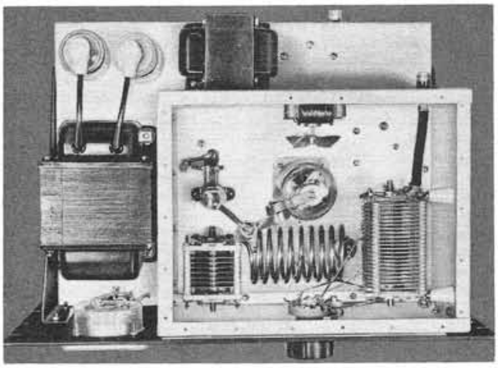
fier, connect it to the exciter and to a 50-ohm antenna-feed line or 200-watt, 50-ohm dummy load. Mesh the plates of the loading capacitor (C_{18}) to unload the tube, throw the meter switch to the "PLATE CURRENT" position, and then apply heater and plate voltage to the 7094. With no excitation applied, the plate current should be 35 to 40 milliamperes.

Switch the meter to read grid current, apply a single-tone modulating signal to the exciter, and quickly adjust the drive to the amplifier until the grid current of the 7094 is approximately 50 milliamperes. Then immediately switch the meter to read plate current and tune the plate tank for minimum current.

Reduce the loading capacitance, keeping the plate tank tuned, until the plate current is approximately 100 milliamperes. Increase the drive to obtain 80 milliamperes of grid current.

Adjust the loading and plate-tank tuning to obtain a resonant plate current of 200 milliamperes, keeping the grid current at 80 milliamperes.

When supplied with 15 watts of driving power and adjusted as described above, the amplifier delivers a peak envelope power of approximately 200 watts to the antenna. Third-order distortion products under these conditions are 35 db below the two-tone signal level. An exciter delivering less than 15 watts P.E.P. may be used, provided the loading for the 7094 is reduced sufficiently to maintain a 2.5-to-1 ratio between plate current and grid current.


Here is a top view of the linear amplifier, with the rf enclosure cover removed.

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Harvey Slovik, Editor

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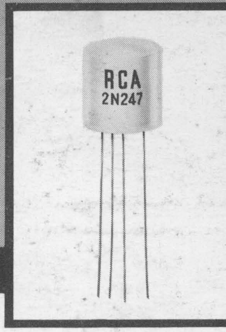


A TWO-TRANSISTOR REGENERATIVE RECEIVER

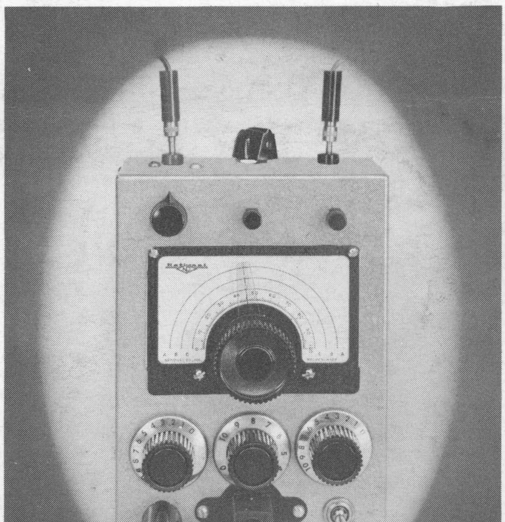
For 80 and 40 Meters

By E. M. Washburn, W2RG*

The operating enjoyment on 80, 40, and 15 meters provided by the transistorized QSO-getter described in my article for the July, 1957, issue of HAM TIPS prompted the construction of a companion transistor receiver.

It seemed desirable that the receiver be a superheterodyne, and literature was searched for a suitable circuit. Although several promising circuits were found, they all had the same shortcoming: they required more transistors and other components than would fit readily into a cabinet as small as the one used for the transmitter. The July, 1957, issue of QST, however, contained a description of a transistorized regenerative "reflex" receiver built by W6WXU. It seemed to provide the answer. This receiver used only two transistors (a 2N107 and a 2N170) and two 1N60 diodes, and was built in a case small enough to be held in the palm of one hand.

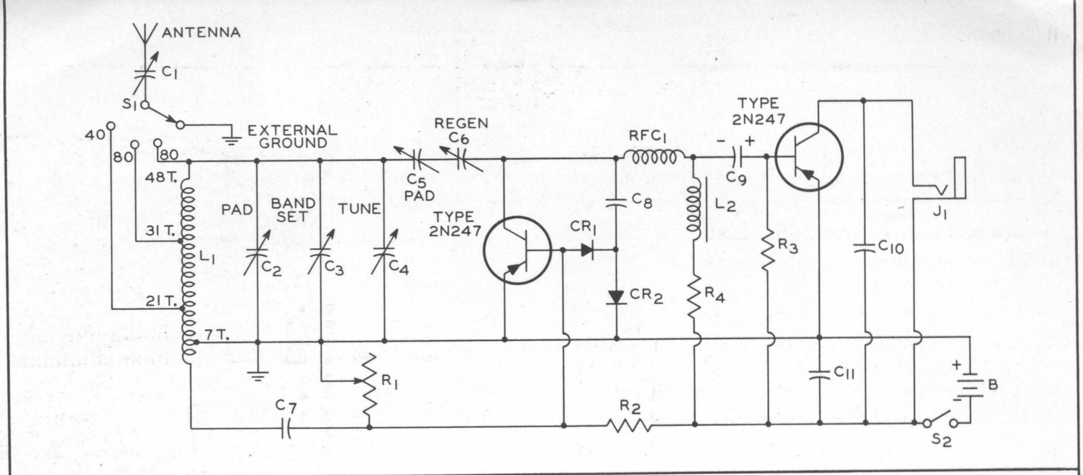
A breadboard receiver was constructed, using the basic circuit of W6WXU's receiver with modifications to suit the components on hand. Two RCA-2N247 p-n-p DRIFT FIELD transistors were used in place of the 2N107 and 2N170, the two diodes were changed to type 1N34's, and a B & W Type 3015 Miniductor was used as the antenna coil in place of the hand-wound ferrite-rod antenna used in the original. A small output transformer with primary and secondary connected in series was used instead of the 2-henry choke.



Front view of W2RG's receiver. The two transistors are mounted externally just above bandspread tuning dial.

This breadboard model worked so well that it was rebuilt in a 7- by 5- by 3-inch Minibox, as shown in the accompanying photographs. The receiver covers 3.3 to 8.5 Mc in three ranges which can be adjusted by means of the bandsetting capacitor to provide continuous coverage or separate bandspread coverage

*Manager (Retired), Frequency Control Engineering, RCA, Camden, N. J.



B_1—Battery, 6 volt, heavy duty (RCA-VS009 or equiv.)
C_1—0-50 $\mu\mu$f, variable
C_2—7-45 $\mu\mu$f, ceramic variable (Erie type N500 7-45 or equiv.)
C_3—0-75 $\mu\mu$f, variable
C_4—0-20 $\mu\mu$f, variable
C_5—1.5-7 $\mu\mu$f, ceramic variable (Erie type NPO 1.5-7 or equiv.)
C_6—0-50 $\mu\mu$f, variable
C_7—270 $\mu\mu$f, mica
C_8—220 $\mu\mu$f, mica
C_9—8 μf, electrolytic
C_{10}—0.01 μf, ceramic disc
C_{11}—0.01 μf, ceramic disc
CR_1, CR_2—Crystal diode, type 1N34 or equiv.
J_1—Phone jack, open circuit
L_1—48 turns, B & W Miniductor #3015, tapped as shown
L_2—AF choke, 2 henrys
R_1—Bias control, 10,000 ohm potentiometer
R_2—220,000 ohms, ¼ watt
R_3—270,000 ohms, ¼ watt
R_4—270 ohms, ½ watt
RFC_1—2.5 millihenrys, rf choke
S_1—Wafer switch, single-pole, four position
S_2—On-off switch, SPST

Figure 1: Schematic diagram and parts list of W2RG's two-transistor 40- and 80-meter receiver.

for the upper and lower halves of the 80-meter band and for the 40-meter band.

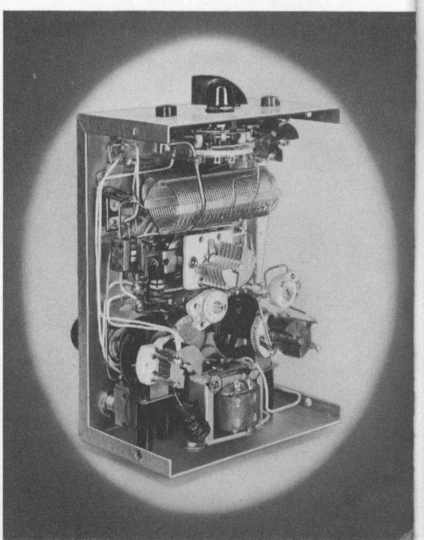
Circuit Description

The circuit of the receiver is shown in Figure 1. The rf section includes the antenna coil L_1; the padding, bandsetting, and tuning capacitors C_2, C_3, and C_4, respectively; the first type 2N247 transistor; the two crystal diodes, and the regeneration-control capacitors C_5 in series with C_6. The remaining components comprise the "reflex" and af-amplifier portions of the receiver. R_1 controls the bias on both transistors. According to the description of W6WXU's receiver in QST, the first transistor acts as a regenerative amplifier feeding the two series-connected crystal diodes. The af voltage appearing across the grounded diode is fed back to the first transistor (through the base), amplified, and reamplified in the second transistor. We have not questioned this very brief explanation because one thing is certain: the receiver works beautifully.

Construction Details

The arrangement of the major controls and components is shown on page 1 in the front view of the completed receiver. From left to right across the top of the cabinet are the antenna jack, band-selector switch (S_1), and ground-connection jack. Above the tuning dial are the antenna-trimmer capacitor C_1, and the two RCA-2N247 transistors. Just below the dial are the band-setting capacitor C_3, the transistor-bias control R_1, and the regeneration control C_6, and across the bottom are the phone jack, power-supply connector, and ON-OFF switch S_2.

The photographs on pages 2 and 3 show the internal construction. Hand-capacitance effects in tuning are eliminated by the National dial for the band-spread capacitor, and by the use of flexible couplings and bakelite extension shafts for the antenna-trimmer, band-setting, and regeneration-control capaci-



Inside view of the receiver, showing placement of major components.

tors. To assure mechanical stability, the antenna-trimmer, band-setting, and regeneration-control capacitors are rigidly mounted on brackets and stand-off insulators, and smaller components are supported by heavy bus-bar wire.

All 48 turns of the B & W Type 3015 Miniductor are used for the antenna coil, L_1. Turns adjacent to the two tap points and the ground connection are depressed to permit clean soldering of connections at these points without danger of shorted turns. The electrolytic capacitor, band switch, flexible couplings, and resistors shown in the photographs are larger than necessary, because I simply used whatever parts were at hand.

Operation

The only power supply needed for the receiver is a 6-volt battery, which may be the same as that used for the transmitter. Although an antenna may not be necessary, a good external ground connection is essential to eliminate phone-cord body-capacitance effects. If an antenna is used, it should be only a very short length of wire—not the transmitting antenna—and should be very loosely coupled to the antenna coil.

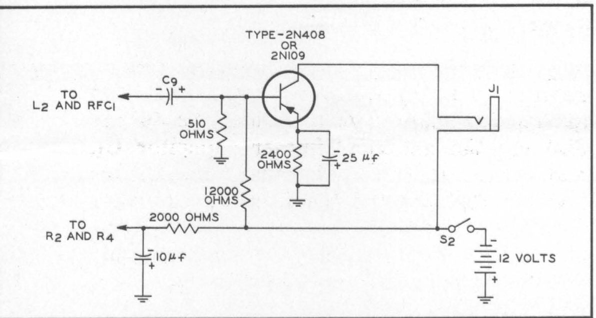
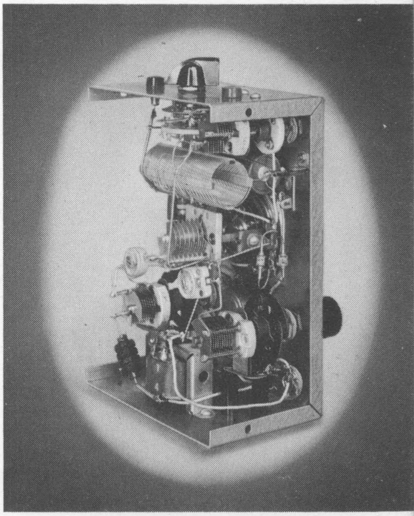


Figure 2: Modified output circuit for operation of W2RG's receiver with 12-volt dc supply.

The receiver performs best on CW signals. For most stable performance, the bias and regeneration controls should be advanced well beyond the threshold of oscillation. For very weak signals, it will be necessary to work closer to the oscillation point. For phone signals, as in any regenerative receiver, the regeneration control should be set just below the oscillation point. Weak phone signals, however, are difficult to copy.

High-resistance headphones should not be used with the receiver because they cause motor-boating and make it difficult to maintain smooth control of oscillation. Phones having a dc resistance of about 135 ohms, such as the Trimm Z-300, are satisfactory and provide plenty of volume on most ham signals, even with a 6-foot antenna.



Inside view of the receiver, showing mounting of the two-crystal diodes.

To avoid burnout of the transistors, it is absolutely essential that the bandswitch be set in its "EXTERNAL GROUND" position before transmitting, and whenever the receiver is not being used. If even a moderately high-power transmitter is being used in the vicinity of the receiver, the receiving antenna should be disconnected.

When the receiver is first turned on, its tuning drifts slightly, and both the bias and regeneration controls may require readjustment. During transmitting periods, the receiver frequency tends to move upwards, so that when you turn it over to the other chap and throw the band-selector switch to either the 40- or 80-meter band, you have to retune slightly in the downward direction.

Nevertheless, the receiver has proved to be well worth the effort and expense that went into its construction. With its companion 300-milliwatt transistorized transmitter, it has provided many two-way QSO's over distances up to 1,000 miles, and many European ham stations on 40 meters have been copied during evening hours.

Modifications

If operation from a 12-volt battery is desired, the circuit should be modified as shown in Figure 2, and either an RCA-2N408 or -2N109 transistor used in place of the 2N247 in the output stage of the receiver.

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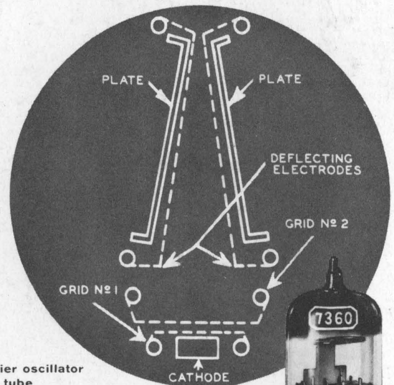

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RCA HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. 20, NO. 2 MAY, 1960

A Low-Cost, One-Tube Walkie-Talkie

With Transistorized Audio Stages

By Martin L. Kaiser, W2VCG

RCA Laboratories, Princeton, N. J.

Interested in small-sized, low-cost walkie-talkies? Then you may find the newly developed 28-megacycle unit described in this article especially suited to your requirements.

An outstanding feature of this walkie-talkie is its economy. Complete with tube, transistors, and batteries, cost of unit is less than $30.

Evolved from numerous units constructed by the writer over the last decade, this walkie-talkie features a unique application of two RCA-2N407 germanium p-n-p alloy junction transistors in combination with an RCA-6AK5 sharp-cutoff pentode.

Under normal operating conditions, the walkie-talkie can achieve a range of about five miles; receiver sensitivity is ½ microvolt.

The 28-megacycle band was selected for the following reasons:

(1) Operation at 28 Mc permits use of a conveniently sized, easily portable antenna.

(2) On the crowded lower-frequency bands, QRM is difficult to overcome with only 1-watt output.

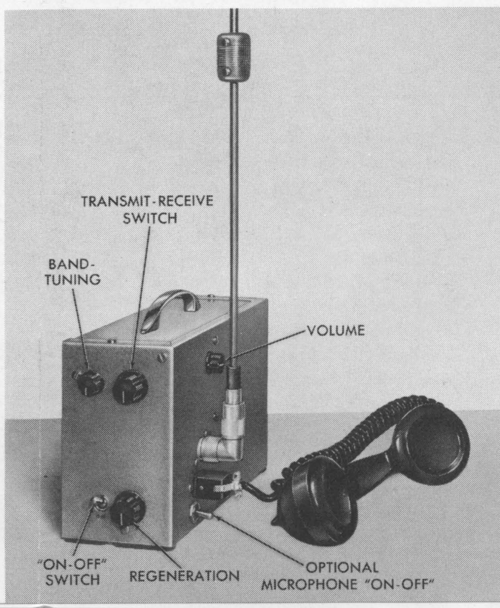
(3) At higher frequencies, coil placement and lead length are extremely critical, and special VHF construction procedures must be followed.

Receiver Circuit

As shown in Figure 1, a single 6AK5 tube is used in the circuits of both a superregenerative receiver and a modulated tri-tet oscillator in the transmitter. The circuit of the regenerative-type receiver is conventional.

Regeneration is obtained by feeding some of the signal from the plate coil (L_6) to the grid coil (L_4). The amount of regeneration is determined by the setting of R_{11}, a 100,000-ohm potentiometer; this control is set just below the point of oscillation. This point will vary with the frequency to which the receiver is tuned. The audio signal appears across the plate-load resistor (R_5) and the volume control (R_6) and is transferred through C_8 to the base of the 2N407 emitter-follower.

Figure 2 shows the chassis layout for all major components. After these components have been mounted, the 6AK5 socket and the TR (Transmit-Receive) switch are connected

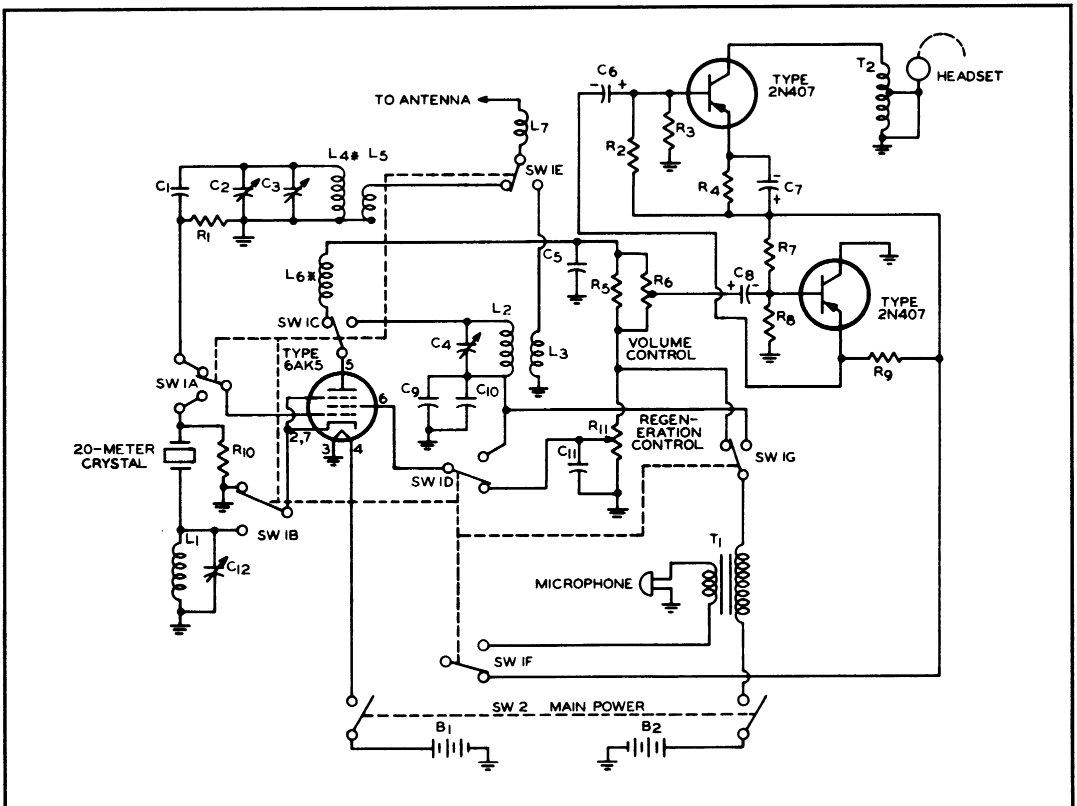


by a small cable consisting of five 4-inch wires. These wires must be connected to pins 1, 2, 4, 5, and 6 at the tube socket. Pins 2 and 7 are connected together at the socket; pin 3 is soldered to the copper support bracket. Leads carrying dc and audio frequencies are soldered to common terminals at the rear of the TR switch, while leads carrying radio frequencies (leads from pins 1, 5, and 6, for example) are soldered to common terminals of the switch nearest the tube.

After these leads are connected to the switch, all coils (L_1 through L_6) are mounted securely. Coil L_1 should be mounted close to the crystal and, together with L_2 and L_3, as far as possible from metal surfaces.

Coverage of C_2, the main band-tuning capacitor, can be determined experimentally. The combination shown in this unit will tune the 28.5-to-29.7 Mc portion of the band.

After L_4 is wound, the windings should be secured with coil "dope." Then, when the



B_1—Two batteries (RCA VS065)
B_2—Two batteries (RCA VS016)
C_1—100 $\mu\mu$f, mica
C_2—Johnson 5M11
C_3, C_4, C_{12}—7-45 $\mu\mu$f (Centralab type 822-BN or equiv.)
C_5—0.005 μf, ceramic
C_6—2 μf/15 volts, electrolytic
C_7—100 μf/15 volts, electrolytic
C_8—4 μf/150 volts, electrolytic
C_9, C_{11}—0.001 μf, ceramic
C_{10}—470 $\mu\mu$f, mica
E and M—Standard telephone headset
L_1—½" inside diameter, 14 turns of No. 20 wire
L_2—½" inside diameter, 6 turns of No. 20 wire
L_3—½" inside diameter, 4 turns of No. 20 wire
L_4—⅝" inside diameter, 8 turns of No. 18 wire
L_5—½" inside diameter, 5 turns of No. 20 wire
L_6—3 turns of number 18 wire on L_4
L_7—¾" long 1" inside diameter, 12 turns of No. 20 wire
R_1—1,200,000 ohms, ½ watt
R_2, R_5—5,600 ohms, ½ watt
R_3, R_9—10,000 ohms, ½ watt
R_4—220 ohms, ½ watt
R_6, R_{11}—100,000-ohm, ½-watt potentiometer
R_7—47,000 ohms, ½ watt
R_8—270,000 ohms, ½ watt
R_{10}—30,000 ohms, ½ watt
$SW_{1A, B, C, D, E, F}$—rotary type, eight-pole, two-position
SW_2—toggle, DPST
T_1—Carbon microphone transformer (Stancor A-4713 or equiv.)
T_2—UTC-A25 transformer, see text
Xtal—20 meter; must fall in band when doubled.

Figure 1: Schematic diagram and parts list of W2VCG's one-tube walkie-talkie with transistorized audio stages.

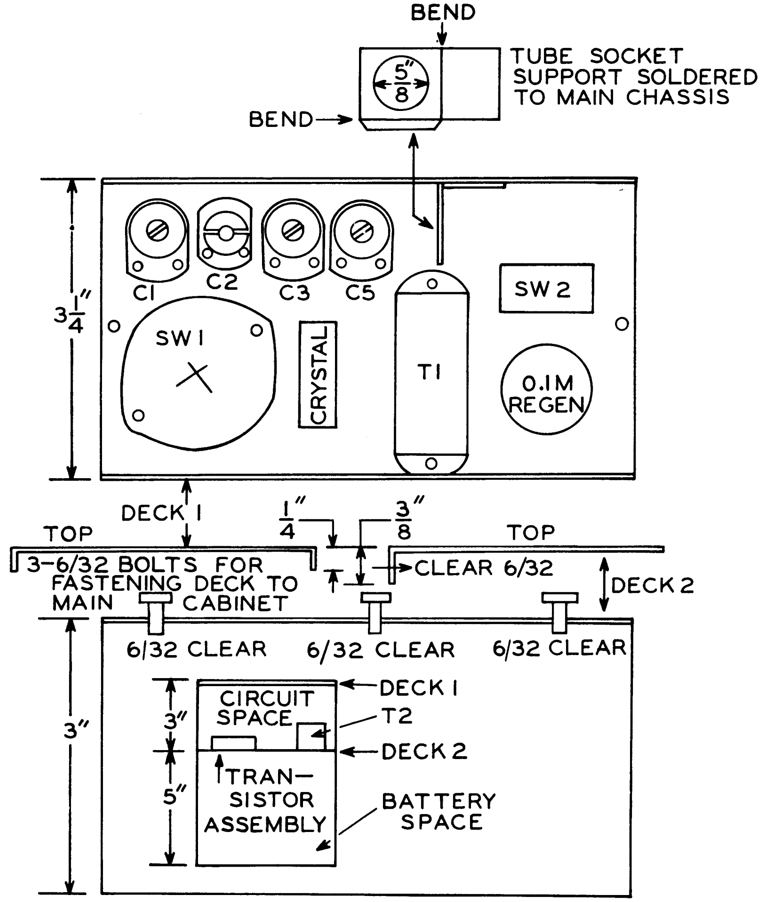


Figure 2: Chassis layout for all major components in author's walkie-talkie.

cement has dried, L_6 is wound in the same direction and on top of L_4 at the ground end. L_6 is cemented securely to L_4. When L_4 and L_6 are wired, the two outermost leads of the coil combination go to the grid and plate circuits of the 6AK5. The end of L_4 nearer L_6 should be grounded, and the other end connected to the grid circuit. The end of L_6 nearer the ground end of L_4 goes to the plate. If this wiring arrangement is not followed, the circuit will not operate.

Audio stages are wired on a separate subassembly, as shown in the photograph on page 5. The audio stages appear in the bottom left portion of the photo; the audio driver transformer is shown at the bottom right.

T_2 is a UTC-A25, although a similar transformer may be substituted. The UTC-A25 has a 600-ohm winding with multiple taps, one of which is 75 ohms. The 600-ohm winding closely matches the impedance of the 2N407 driver, and the 75-ohm tap closely matches the impedance of a standard telephone-headset earpiece. Voltages are fed to the emitters of the transistors and the collectors held at ground potential. This arrangement permits the telephone headset to be connected in the ground lead of the output transistor. The other 2N407 is an emitter-follower which drives the low-impedance base of the audio-output stage from the high-impedance output of the 6AK5. L_7 is wound with uniform spacing on the loading-coil form shown in the antenna diagram, Figure 3. It is then sprayed with a heavy layer of Krylon.

The volume control does not attenuate all the audio, but lowers it to a comfortable level. With the audio gain at maximum, there is sufficient drive to overcome practically all extraneous noise.

After the receiver is wired it should be tested and any necessary adjustment made before the transmitter circuit is wired. The battery drain during the "receive" cycle is 160 milliamperes for the A cells, and about 15 milliamperes for the B cells.

Transmitter Circuit

After the coils for the transmitter are connected, it is good practice during tuning to simulate the side of the chassis by placing a piece of sheet metal next to any coil which will come within 1 inch of the case. When wiring has been completed on the transmitter

section, voltages and currents should be tested. The battery drain should average 200 milliamperes for the A cells and 18 milliamperes for the B cells.

With the TR switch in the transmit position, the 7.5-volt supply is placed across the primary of T_1, which is in series to ground through the 200-ohm microphone of the headset. This connection provides enough power transfer to modulate the unit fully. In the "receive" position, T_1 has no effect on the circuit, except to increase audio choking. The transmitter should be tuned with the aid of a grid-dip meter or some other type of rf detector. To make certain the unit is crystal-controlled, remove the crystal several times while watching rf output. The output should drop to zero when the crystal is removed. C_1 sets the excitation level for the crystal and is fixed at mid-range.

You need not stretch your imagination to find numerous occasions for the use of this novel walkie-talkie. In addition to providing many hours of pleasant entertainment, it can serve as a vital means of communication during emergencies.

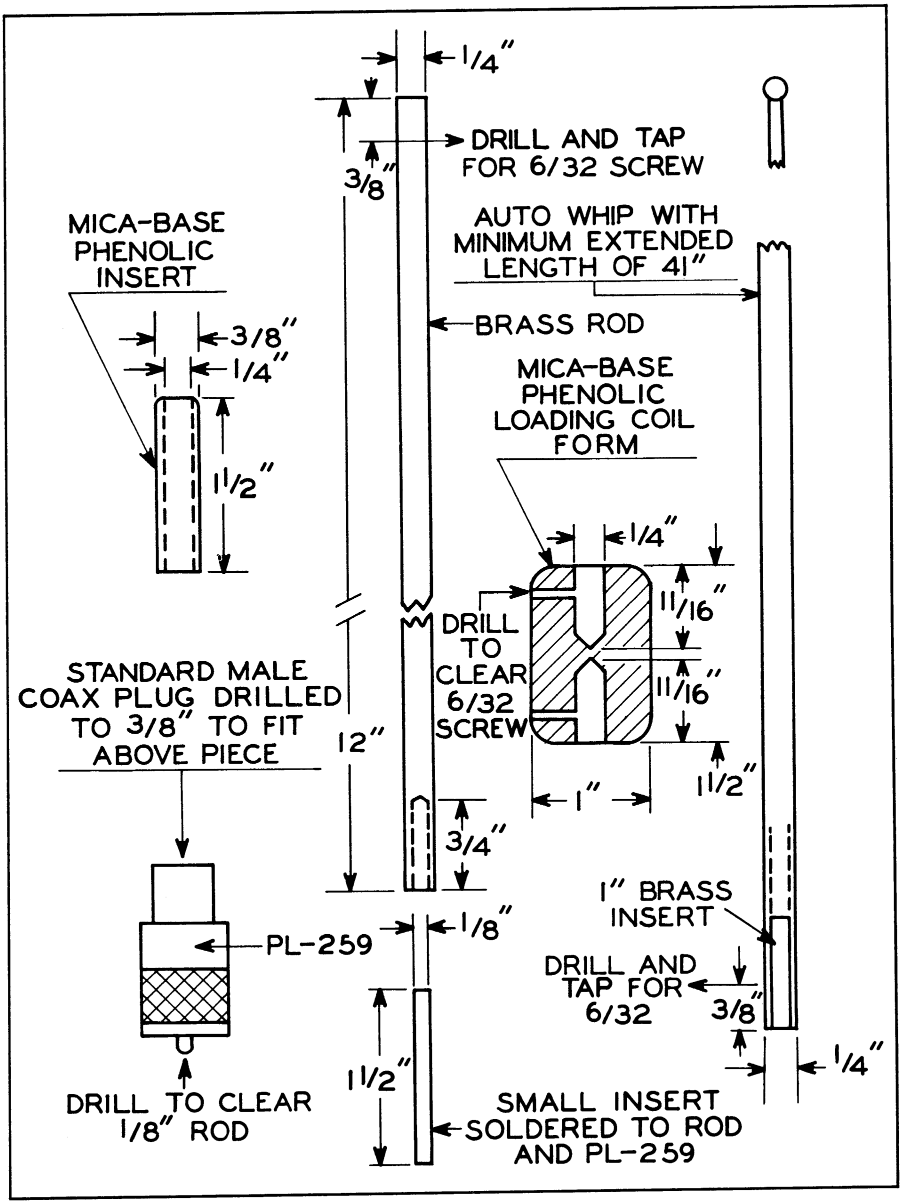
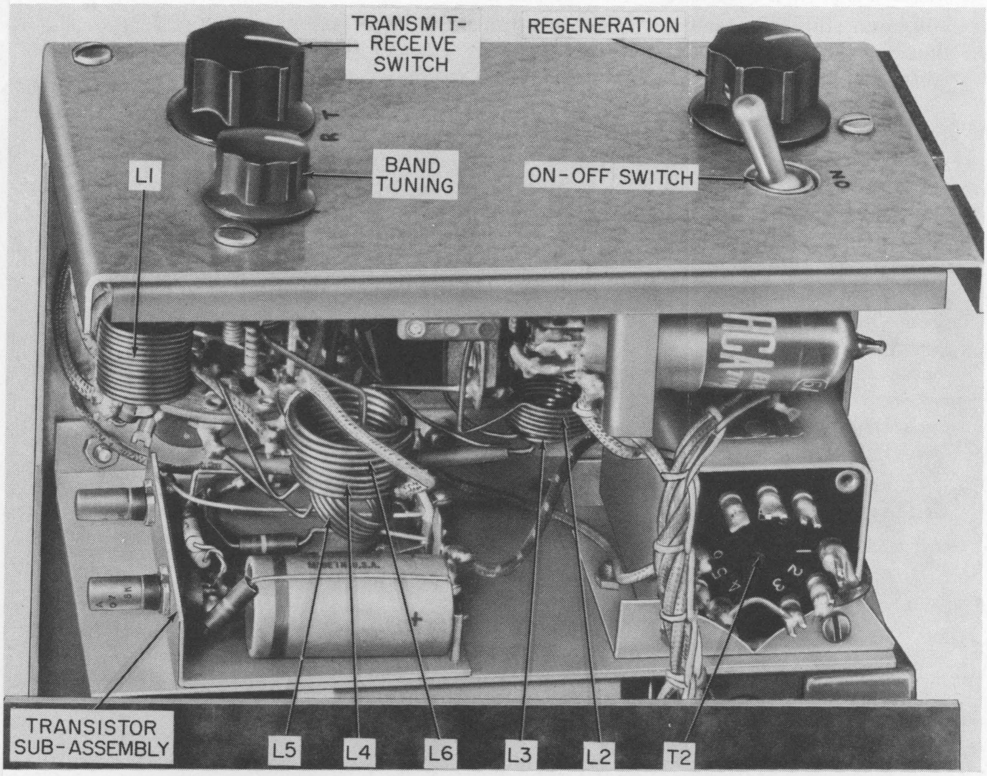
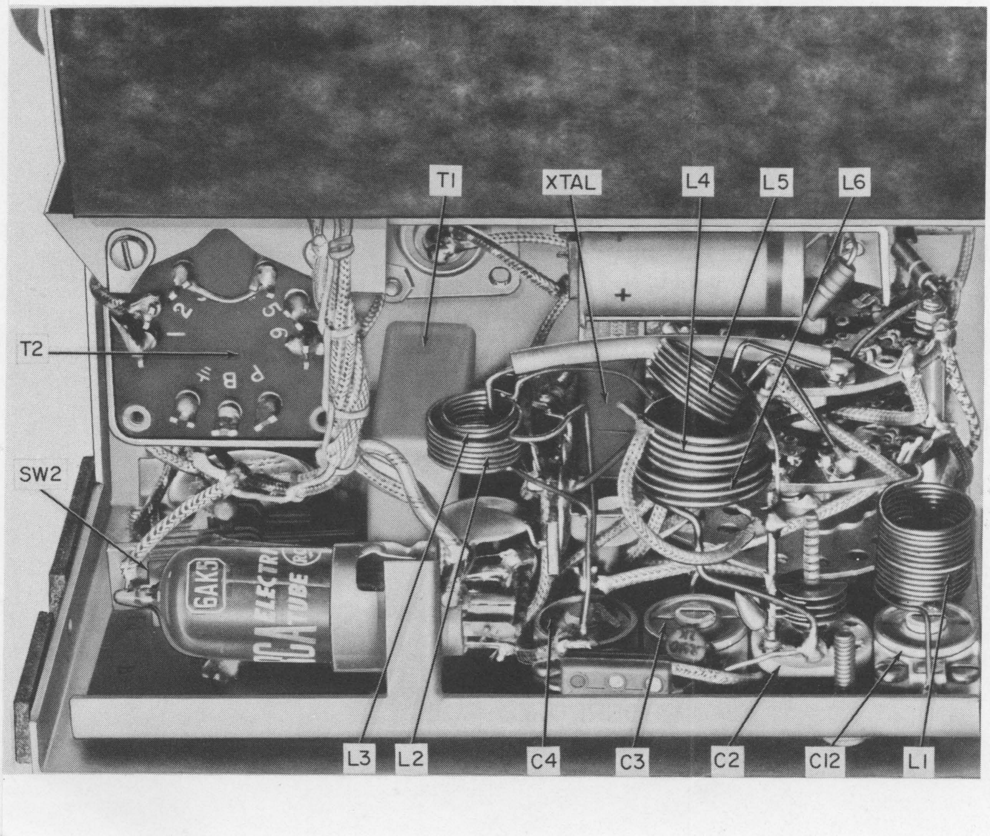


Figure 3: Antenna assembly.



As noted in the text, W2VCG has wired the audio stages on a separate subassembly. This photo shows the audio stages at bottom left, the audio drive transformer at bottom right.



Inside view of walkie-talkie showing placement of components.

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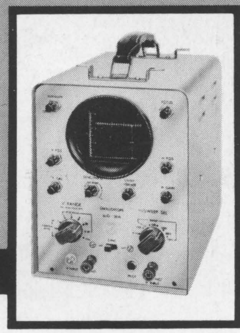


AN RF MODULATION MONITOR:

Modified RCA WO-33A 3-Inch Oscilloscope

By R. A. Rainboth, WV2LNQ, and J. F. Sterner, W2GQK

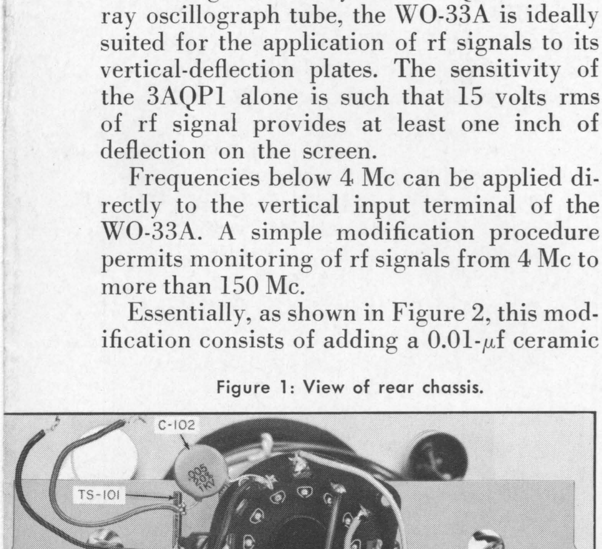
RCA Electron Tube Division, Bldg. 60, Camden, N. J.

RCA's new WO-33A 3-Inch Oscilloscope, which is available both as an easy-to-assemble kit and as a completely-wired, factory-calibrated instrument, has proved excellent for amateur radio use. Because of its plate coupling network (L-2 and R-33 in Figure 4), and the high sensitivity of the 3AQP1 cathode-ray oscillograph tube, the WO-33A is ideally suited for the application of rf signals to its vertical-deflection plates. The sensitivity of the 3AQP1 alone is such that 15 volts rms of rf signal provides at least one inch of deflection on the screen.

Frequencies below 4 Mc can be applied directly to the vertical input terminal of the WO-33A. A simple modification procedure permits monitoring of rf signals from 4 Mc to more than 150 Mc.

Essentially, as shown in Figure 2, this modification consists of adding a 0.01-μf ceramic disc capacitor (C-101) as a high-frequency bypass from cathode to ground, and a 0.005-μf ceramic disc capacitor (C-102) as a safety device to insure against excessive voltage being applied to the 3AQP1. A 4- to 40-$\mu\mu$f ceramic trimmer capacitor (C-103) is mounted on the rear of the WO-33A case for use as a gain control to provide fine adjustment of the rf carrier applied to the 3AQP1 vertical-deflection plates.

Figure 1: View of rear chassis.



Specifically, the modification of the WO-33A as an rf modulation monitor consists of 14 steps, as follows:

(1) Carefully remove instrument from case.

(2) Install the two-lug terminal strip, TS-101, under the left-hand screw (as viewed from rear) holding the 3AQP1 support bracket. Position as shown in Figure 1.

(3) Connect C-101, the 0.01-μf disc capacitor, between lug #3 of the 3AQP1 and the grounded lug of TS-101 (attached to chassis). Solder the connection to lug #3 of the 3AQP1.

(4) Connect C-102, the 0.005-μf disc capacitor, between lug #6 of the 3AQP1 and the insulated lug of TS-101. Solder the connection to lug #6 of the 3AQP1.

(5) Connect one end of a 12-inch length of hookup wire to the grounded lug of TS-101. Solder.

(6) Connect one end of the other 12-inch length of hookup wire to the insulated lug of TS-101. Solder.

These six steps complete the modification to the chassis. As noted, all connections made

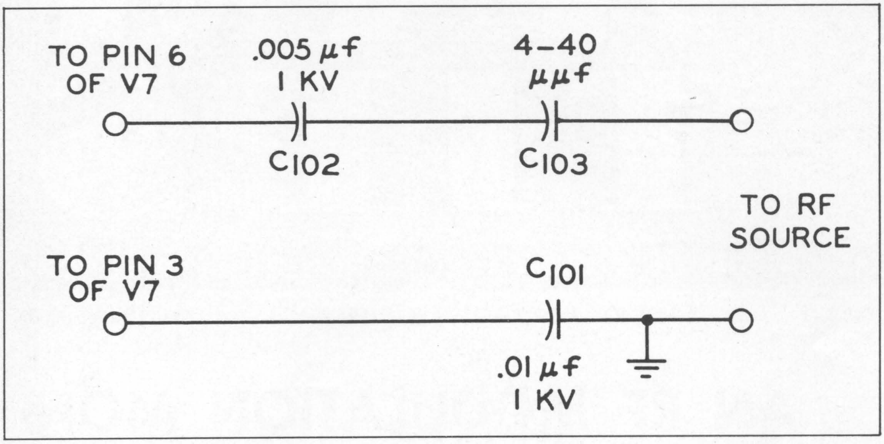


Figure 2: Circuit diagram for modification of WO-33A as an rf modulation monitor.

thus far should be soldered. Check the dress of the two capacitors to insure that the leads do not short against other wires or components. Then:

(7) Remove the knock-out plate on the rear of the WO-33A case.

(8) Locate and mark a point on the rear of the case $2\frac{3}{8}''$ from the top, and $3\frac{1}{4}''$ from either side (center). At this point, drill a $\frac{5}{32}''$ hole for inserting the TS-102 mounting screw.

(9) Mount the four-lug terminal strip (TS-102) on the rear of the case, as shown in Figure 3. Use the #6-32 screw, with the #6 lockwasher and #6 hex nut on the inside of the case.

(10) Replace the instrument in the case, passing the two wires connected to TS-101 through the knock-out hole.

(11) Cut the two wires so that they extend approximately 2 inches outside the case.

(12) Mount the 4- to 40-$\mu\mu$f trimmer capacitor (C-103) on the terminal strip TS-102 between lugs #2 and #4, as shown in Figure 3. (The grounded lug is designated as lug #1.)

(13) Connect the grounded hookup wire to the grounded lug of TS-102 (lug #1).

(14) Connect the other hookup wire to lug #4 of TS-102. Solder lugs #1, #2, and #4 of TS-102. Be sure that good solder connections are made at the two lugs of the trimmer capacitor.

Coaxial cable or 300-ohm TV twinlead may be connected directly from an rf source to lugs #1 (ground) and #2 of terminal strip TS-102 on the rear of the WO-33A case. If coaxial cable is used, connect the braided shielding to lug #1, and the center conductor to lug #2 of TS-102.

When rf signals are applied directly to the vertical plates of the 3AQP1, the vertical input cable should be shorted out and the "Ver-

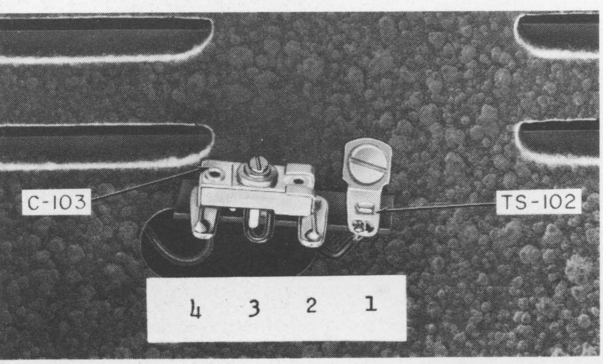


Figure 3: The four-lug terminal strip (TS-102) is mounted on the rear of the case.

To modify RCA's WO-33A 3-Inch Oscilloscope for use in monitoring rf signals from 4 Mc to more than 150 Mc, only a few parts are needed, as follows:

- One C-101 (capacitor, ceramic disc, 0.01 μf, 1 kv)
- One C-102 (capacitor, ceramic disc, 0.005 μf, 1 kv)
- One C-103 (trimmer capacitor, ceramic, 4-40 $\mu\mu$f)
- One TS-101 (terminal strip, two lugs—with one grounded)
- One TS-102 (terminal strip, four lugs—with one grounded lug at end)
- One screw (6-32 x $\frac{1}{4}''$, pan head)
- One #6 internal tooth lockwasher
- One #6 hex nut
- Two insulated hookup wires (12″ length)

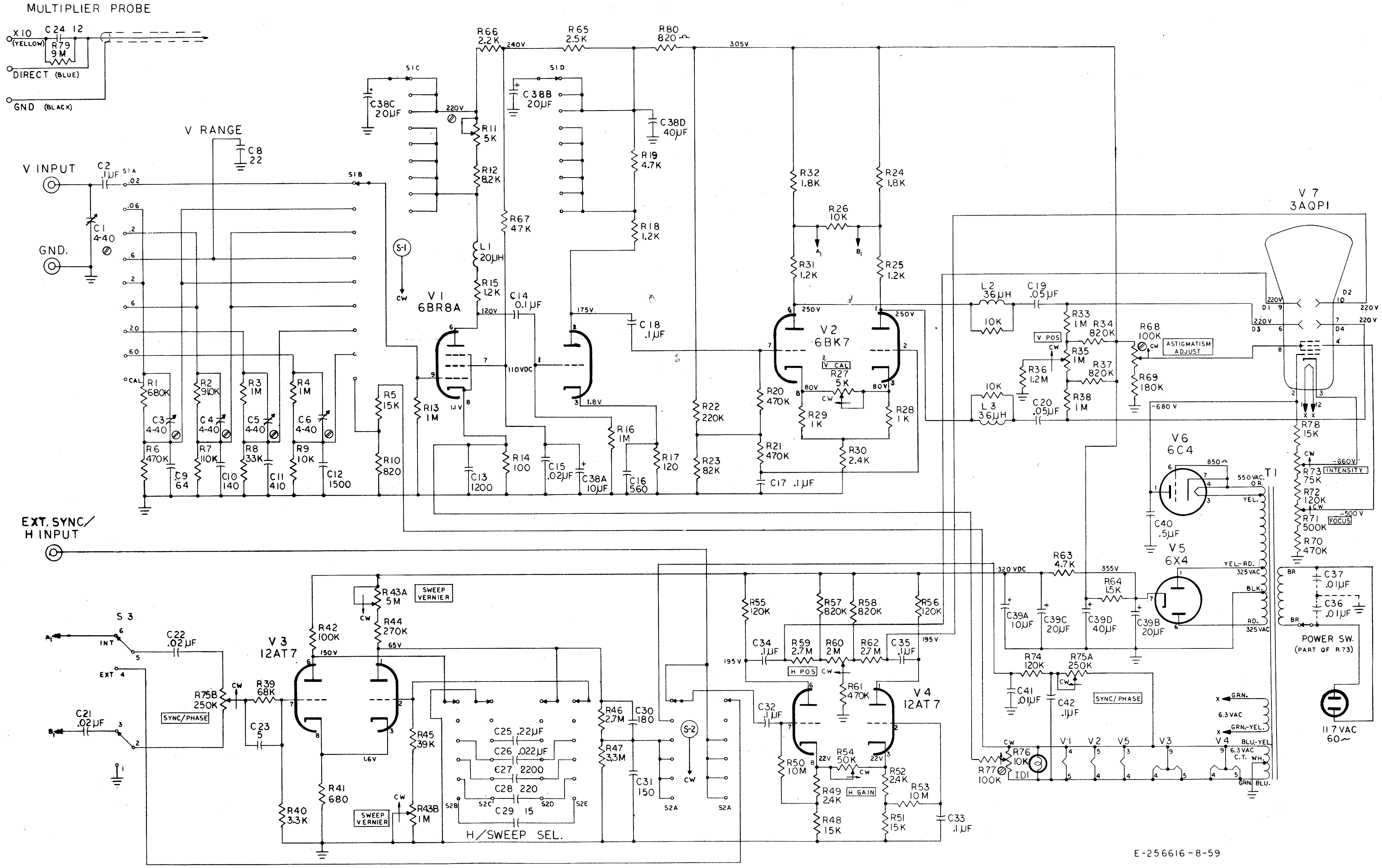
It is suggested that these two 12-inch lengths of hookup wire be of different color for identification purposes.

tical Range" switch set to position "60". The horizontal amplifier and sweep circuits may be adjusted in the normal manner to obtain modulation patterns as desired.

Normal operation of the WO-33A should not be affected by this modification. However, cables or leads connected to the terminal strip on the rear of the case must be removed be-

fore normal operation is resumed; otherwise, performance is affected by the added capacitance of these cables in the V-2 plate circuit.

For information concerning connections to the transmitter, interpretation of the 'scope pattern, and additional rf applications, radio amateurs should consult the ARRL Handbook or similar publications.



V RANGE FULL SCALE VOLTS (P-P) S-1 POSITION	RANGE	
1 (CCW MAX)	0.02	NARROW BAND
2	0.06	NARROW BAND
3	.2	NARROW BAND
4	0.6	WIDE BAND
5	2.0	WIDE BAND
6	6.0	WIDE BAND
7	20	WIDE BAND
8	60	WIDE BAND
9	CAL.	

H/SWEEP SEL. SW. S-2 POSITION	RANGE	
1 (CCW MAX)	HOR. IN.	
2	LINE	
3	15-150	SWEEP
4	150-1500	SWEEP
5	1500-15KC	SWEEP
6	15KC-75KC	SWEEP

SYNC. SW. S-3 POSITION	RANGE
RIGHT	EXT.
LEFT	INT.

NOTES

ALL CAPACITORS IN μμF, UNLESS OTHERWISE SPECIFIED.
ALL RESISTORS IN OHMS.
ALL VOLTAGES POSITIVE FROM GROUND, AND MEASURED WITH A VOLTOHMYST*
SWITCHES S-1 AND S-2 SHOWN IN MAXIMUM CCW POSITION
INSTRUMENTS WITH SERIAL NO.'S 1001 THRU 2300 HAVE TWO 0.01 μF DISC CAPACITORS BETWEEN THE AC LINE AND CASE GROUND

* TRADE-MARK "VOLTOHMYST" REG. U.S. PAT. OFF.

Figure 4: Schematic diagram of WO-33A and WO-33A(K).

HALF-KILOVOLT RF PROBE

By Joseph Talavage

RCA Semiconductor and Materials Division, Somerville, N. J.

A 500-volt rf probe, useful for obtaining the resonance point of transmitter tank circuits, grid circuits, and other high voltage rf circuits, can be easily constructed with readily available components and two silicon rectifiers. Figure 5 shows the simple schematic diagram for the probe.

RCA-1N1764 silicon rectifiers are used in the probe. Because these rectifiers have a peak inverse voltage of 500 volts each, the two connected in series permit the probe to be useful to peak voltages of 500 volts, or about 350 volts rms. The addition of more rectifiers raises the peak-voltage rating of the probe by 250 volts for each additional rectifier, a decided advantage over a typical crystal-diode rf probe which has a maximum operating voltage of about 28 volts peak.

Circuit operation is such that the dc output of the probe is proportional to the peak value of the input wave. For this reason, and because of the value selected for R_1, best accuracy is obtained when the input wave is sinusoidal.

An increase in the value of C_1 will extend the low-frequency response, but will also affect the accuracy of the reading. However, if C_1 is increased in value, the accuracy of the probe can be adjusted to an optimum value by means of compensating changes in the value of R_1.

The probe circuit can be constructed to fit easily inside a discarded low-capacitance probe case. It was connected directly to an RCA WV-98A Senior *VoltOhmyst®*, through a shielded cable, and tested over a frequency range from 5 kilocycles to 50 megacycles, and a voltage range from 0.4 to 50 volts rms. Figures 6 and 7 show that for frequencies to 50 Mc, the greatest accuracy is obtained at voltages greater than 3 volts. The loading effect of the probe on resonant tank circuits was found to be negligible to at least 10 Mc.

Although all the tests were made with only one rectifier in the probe, the accuracy above 3 volts is relatively unaffected by the addition of the second rectifier.

Use of the probe involves a few simple steps: (1) place the selector switch of the VTVM in the "—DC" position; (2) apply the probe tip and ground wire to the correct points; and (3) read the *rms* value of the rf voltage on the appropriate dc scale.

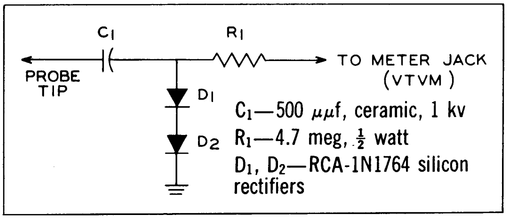
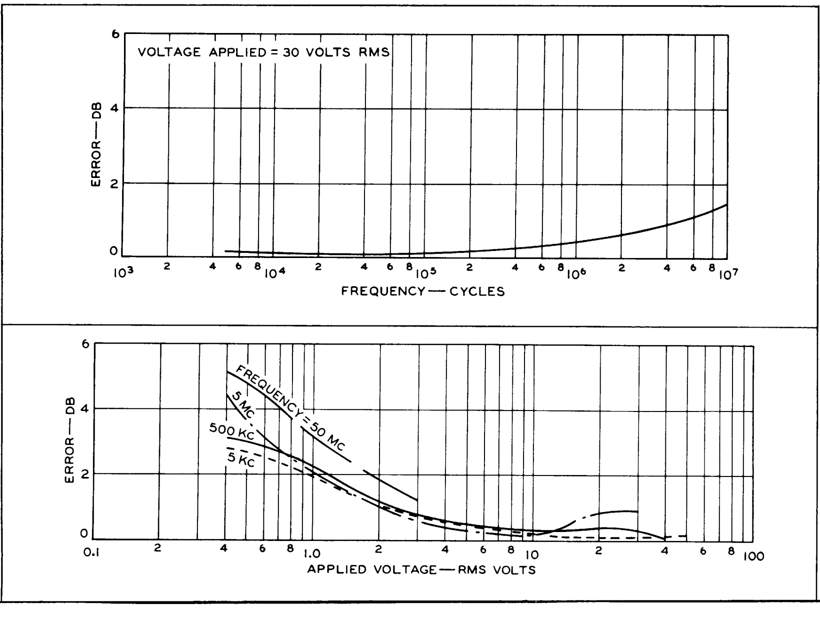


Figure 5: Simple schematic diagram and parts list of author's half-kv rf probe.



Figures 6 (top) and 7, as noted in text, show that for frequencies to 50 Mc, the greatest accuracy is obtained at voltages over 3 volts.

From your local RCA distributor, headquarters for RCA receiving and power tubes.

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Harvey Slovik, Editor

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HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. 20, NO. 4

DECEMBER, 1960

DETERMINATION OF TYPICAL OPERATING CONDITIONS

For RCA Tubes Used as Linear RF Power Amplifiers

Part I

By Claude E. Doner, W3FAL

RCA Electron Tube Division, Lancaster, Pa.

During the past few years, ham interest in single-sideband transmission has been on a continual upswing. As a result, numerous articles have been published on the theory and construction of linear triode and tetrode amplifiers. While these articles have discussed classes of tube operation and compared grid-drive to cathode-drive circuits, only a handful provided design information for adapting tube manufacturers' data to available components or to the amateur's specific requirements.

Included among the "selected few" was an article by A. P. Sweet, which appeared in the December, 1954, issue of HAM TIPS. It presented such information in the form of step-by-step calculations for use in converting published maximum ratings to typical operating conditions.

Now, six years later, having recognized the need to bring this design information up to date, HAM TIPS is pleased to offer here Part I of a two-part article prepared by W3FAL. This first part extends the calculations to include cathode-drive (grounded-grid) operation of tetrodes and triodes in class AB_1 service.

In the next issue, Part II will cover the procedure for calculating typical operating conditions for class B operation of triodes or triode-connected tetrodes in a cathode-drive circuit.

Sample calculations are based on published data and curves for the RCA-7094 power tetrode. Also included is a chart which lists maximum ratings and typical operating conditions for several widely used RCA power tubes.

Class AB_1 Operation of Tetrodes (Grid-Drive Circuit)

When it is desirable to operate tubes at conditions other than those given in the published data, typical operating conditions can be calculated from the maximum ratings and characteristics curves. The calculations required for class AB_1 operation of a tetrode in grid-drive service are given below. This procedure may be adapted to triode tube types by eliminating the terms E_{c2}, I_{c2}, i'_{c2}, and SI from the calculations.

(1) Make sure that E_b is within maximum ratings. (E_b is one of 21 symbols defined on page 2.)

(2) On the average plate-characteristics

curves, select a point near the "knee" of the curve for zero control-grid voltage; record i'_b and e_{bmin}. From the average screen-grid characteristics curves, determine i'_{c2} for this point; record E_{c2} for the curves used.

(3) Calculate I_{bms}: $I_{bms} = i'_b/3$.

(4) Calculate PD: $PD = (I_{bms}/4)(E_b + 3 e_{bmin})$.

(5) Calculate SI: $SI = E_{c2} i'_{c2}/4$.

(6) Calculate PI: $PI = E_b I_{bms}$.

(7) Check the values obtained in steps 3 through 6 to determine whether they are within tube ratings. If either I_{bms}, PI, or PD is out of ratings, select a point slightly lower than the original point on the knee of the curve for zero control-grid voltage and recalculate steps 2 through 6. If only SI is out of ratings, select a point slightly higher on the knee. If SI and either I_{bms}, PI, or PD are out of ratings, select a lower value of i'_b (either in the negative-control-grid region or at a lower screen-grid voltage) and repeat steps 2 through 6.

(8) Calculate PO: $PO = PI - PD$.

(9) Calculate I_{bo}: $I_{bo} = I_{bms}/5$.

(10) Determine E_{c1} from the plate-characteristics curves as the control-grid voltage at which the plate voltage is E_b and the plate current is I_{bo}.

(11) Calculate E'_g: $E'_g = |E_{c1}| + e_{cm}$. This value of E'_g is equal to the absolute value of E_{c1} (the straight lines around this term indicate that its plus or minus sign may be ignored) plus the algebraic value of e_{cm} (include the sign). If the point selected in step 2 was on the curve for zero control-grid voltage, then e_{cm} is equal to zero and $E'_g = |E_{c1}|$.

(12) Calculate I_{c2}: $I_{c2} = i'_{c2}/4$.

(13) Calculate DP: $DP = E'_g i'_{c1}/4$. (For AB_1 operation, i'_{c1} equals zero; therefore, DP is also zero.) This value of DP does not include rf tube and circuit losses. The power available from the driver, therefore, should be at least 10 times this value in grid-drive operation. Because AB_1 tube driving power is zero, determine the approximate driver-output requirements from published AB_2 typical operating conditions at approximately the same E'_g and operating frequency.

(14) Calculate R_p: $R_p = E_b/1.7\ I_{bms}$.

* * *

E_b	*DC plate voltage (with respect to cathode)*
e_{bmin}	*Minimum plate voltage necessary to produce the required peak current (from the characteristics curves)*
E_{c2}	*DC screen-grid voltage*
E_{c1}	*DC control-grid voltage*
e_{cm}	*Maximum control-grid drive voltage needed to obtain the required peak plate current at a given minimum plate voltage*
E'_g	*Peak value of control-grid voltage swing*
I_{bms}	*Maximum signal, dc plate current*
I_{bo}	*Zero-signal, dc plate current*
i'_b	*Instantaneous peak plate current*
I_{c1}	*Maximum-signal, dc control-grid current*
I_{c2}	*Maximum-signal, dc screen-grid current*
i'_{c1}	*Instantaneous peak control-grid current*
i'_{c2}	*Instantaneous peak screen-grid current*
PD	*Plate dissipation at maximum signal*
PD_o	*Plate dissipation at zero signal*
PI	*Plate power input at maximum signal*
PO	*Power output at maximum signal*
P_{ft}	*Feed-through power at maximum signal (cathode-drive operation)*
DP	*Driving power at maximum signal*
SI	*Screen-grid input at maximum signal*
R_p	*Effective rf plate-load resistance*

Example—The following example illustrates the calculation of typical operating conditions for class AB_1 tetrode operation of the RCA-7094 in a grid-drive circuit:

(1) The maximum plate voltage rating is 2000 volts.

(2) From the plate-characteristics curves shown in Figure 1 ($E_{c2} = 350$ volts), select a point PI on the knee of the curve for zero control-grid voltage. At this point, i'_b is 0.650 ampere and e_{bmin} is 300 volts. At the corresponding point on the grid-characteristics curves shown in Figure 2, i'_{c2} is equal to 0.085 ampere.

(3) $I_{bms} = i'_b/3 = 0.217$ ampere.

(4) $PD = (I_{bms}/4)(E_b + 3\ e_{bmin}) = (0.217/4)[2000 + 3(300)] = 157$ watts.

(5) $SI = E_{c2} i'_{c2}/4 = (350)(0.085)/4 = 7.4$ watts.

(6) $PI = E_b I_{bms} = (2000)(0.217) = 434$ watts.

Table I: Ratings and operating conditions for RCA tubes used as linear rf power amplifiers.

Tube Type	Class of Operation	Service	Maximum Ratings—Absolute Values: Plate Voltage (E_b)	Grid-No. 2 Voltage (E_{c2})	Max-Signal Plate Current (I_{bms})—ma	Max-Signal Plate Input (PI)—watts	Max-Signal Grid-No. 2 Input (SI)—watts	Max.-Signal Grid-No. 1 + Grid-No. 2 Current ($I_{c1}+I_{c2}$)—ma	Plate Dissipation (PD)—watts	Grid-No. 1 Resistance—ohms	Typical Operation: Plate Voltage (E_b)	Grid-No. 2 Voltage (E_{c2})	Grid-No. 1 Voltage (E_{c1})	Peak Grid-No. 1 Voltage (E'_g)	Zero-Signal Plate Current (I_{bo})—ma	Max-Signal Plate Current (I_{bms})—ma	Max-Signal Grid-No. 2 Current (I_{c2})—ma	Max.-Signal Grid-No. 1 + Grid-No. 2 Current ($I_{c1}+I_{c2}$)—ma	Drive Power (DP)-watts	Max-Signal Power Output (PO)—watts
2E26	AB$_1$	CCS	400	200	75	30	2.5		10	30 K	400	200	−25	25	9	45	10			12
		ICAS	500	200	75	37.5	2.5		12.5	30 K	500	200	−25	25	9	45	10			15
	AB$_2$	CCS	400	200	75	30	2.5		10		400	125	−15	30	10	75	16		0.2	20
		ICAS	500	200	75	37.5	2.5		12.5		500	125	−15	30	11	75	16		0.2	25
4-65A	AB$_1$	CCS	3000	600	150		10		65	250 K	1000	500	−85	85	15	85	12			40
											1500	500	−85	85	15	90	7			70
											1750	500	−90	90	10	85	9			85
	AB$_2$	CCS	3000	600	150		10		65		1000	250	−30	105	30	150	22		2.5	85
											1500	250	−35	100	30	125	15		1.5	125
											1800	250	−35	90	25	110	13		1.0	135
4-125A	AB$_1$	CCS	3000	600	225		20		125	250 K	1500	600	−90	90	30	110	9			80
											2000	600	−94	94	25	120	3			115
											2500	600	−96	96	25	115	4			165
	AB$_2$	CCS	3000	400	225		20		125		1500	350	−41	141	44	200	17		5.0	175
											2000	350	−45	105	36	150	3		3.0	175
											2500	350	−43	139	47	130	3		2.5	200
4-250A	AB$_1$	CCS	4000	600	350		35		250		2000	500	−88	88	55	200	11			230
											2500	500	−90	90	60	215	7			310
											3000	500	−93	93	60	205	5			370
	AB$_2$	CCS	4000	600	350		35		250		2000	300	−48	100	60	255	13		5.5	325
											2500	300	−51	100	60	250	12		5.0	420
											3000	300	−53	100	62	236	16		4.5	520
807 1625	AB$_1$	CCS	600	300	120	60	3.5		25	100 K	500	300	−32	32	22	70	8			23
		ICAS	750	300	120	90	3.5		30	100 K	600	300	−34	34	18	70	8			28
											750	300	−35	35	15	70	8			35
	AB$_2$	CCS	600	300	120	60	3.5		25		500	300	−30	43	30	120	10		0.2	38
											600	300	−32	40	24	100	9		0.1	40
		ICAS	750	300	120	90	3.5		30		750	300	−35	48	15	120	10		0.2	60
811A	B	CCS	1250		175	165			45		750		0	100	16	175			10	90
											1250		0	78	25	130			4	120
		ICAS	1500		175	235			65		1000		0	93	22	175			7.5	125
											1250		0	88	27	175			6	155
813	AB$_1$	CCS	2250	1100	180	360	22		100		2000	750	−90	80	25	130	20			165
		ICAS	2500	1100	225	450	22		125		2250	750	−95	85	25	125	26			190
											2500	750	−95	90	25	145	27			245
829B Natural Cooling	AB$_1$	CCS	750	225	250	100	7		30	100 K	500	200	−20	40	20	100	20			35
		ICAS	750	225	250	120	7		40	100 K	600	200	−18	36	40	100	18			44
											750	200	−21	42	20	100	20			55
	AB$_2$	CCS	750	225	250	100	7		30		500	200	−18	50	30	180	26		0.6	60
		ICAS	750	225	250	120	7		40		600	200	−20	50	26	155	22		0.4	65
											750	200	−19	50	32	160	25		0.5	85
832A	AB$_1$	CCS	750	250	90	36	5		15	100 K	500	180	−30	60	14	70	7			22
		ICAS	750	250	115	50	5		20	100 K	600	150	−30	60	12	60	7			23
											750	150	−32	64	12	60	7			30
833A	B	ICAS	3300		500	1300			350		3300		−80	190	60	300			20	710
6146 6159	AB$_1$	CCS	600	250	125	60	3		20	100 K	400	190	−40	40	32	114	13			27
											500	185	−40	40	29	108	13			35
											600	180	−45	45	13	100	12			40
											600	200	−50	50	14	115	14			47
		ICAS	750	250	135	85	3		25	100 K	750	195	−50	50	12	110	13			60
	AB$_2$	CCS	600	250	125	60	3		20		400	175	−41	48	17	116	9		0.2	31
											500	175	−44	51	14	121	9		0.3	41
											600	165	−44	49	11	104	9		0.2	45
											600	190	−48	55	14	135	10		0.3	55
		ICAS	750	250	135	85	3		25		750	165	−46	54	11	120	10		0.4	65
6524	AB$_2$	CCS	500	300	150	70	3		20	30 K	400	200	−23	72	25	145	10		0.1	39
											500	200	−26	70	20	116	10		0.1	40
											500	200	−25	76	25	145	10		0.1	50
		ICAS	600	300	150	85	3		20	30 K	600	200	−26	76	21	135	13		0.1	57
7094	AB$_1$	CCS	1500	400	350	300	20		100	30 K	1500	400	−65	60	30	200	35		4	185
		ICAS	2000	400	350	400	20		125	30 K	2000	400	−65	60	30	200	35		4	250
	B*	CCS	1500		350	300		200	100		1350	0	0	50	30	200		140	15	160
		ICAS	2000		350	400		200	125		1750	0	0	50	44	200		140	15	210
7580	AB$_1$	CCS	2000	500	350●		12		250	25 K	2000	400	−77	77	70	225	35		1	400●●

*Triode-connected cathode-drive operation

● During short periods of circuit adjustment under "single-tone" conditions, the average plate current may be as high as 350 ma.

●● Peak envelope power

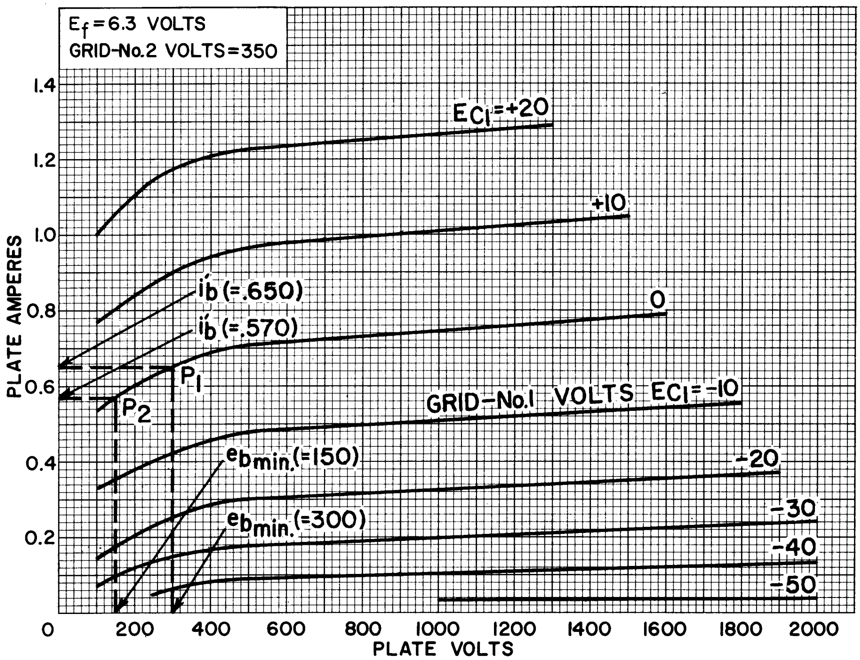

Figure 1: Typical plate characteristics of type 7094.

(7) Because both PD and PI are above the maximum ratings for the 7094, a lower value of i'_b must be used. Select a point P2 below the original point on the knee of the curve for zero control-grid voltage and recalculate steps 2 through 6.

At the new point, i'_b is 0.570 ampere and e_{bmin} is 150 volts. At this point on the grid-

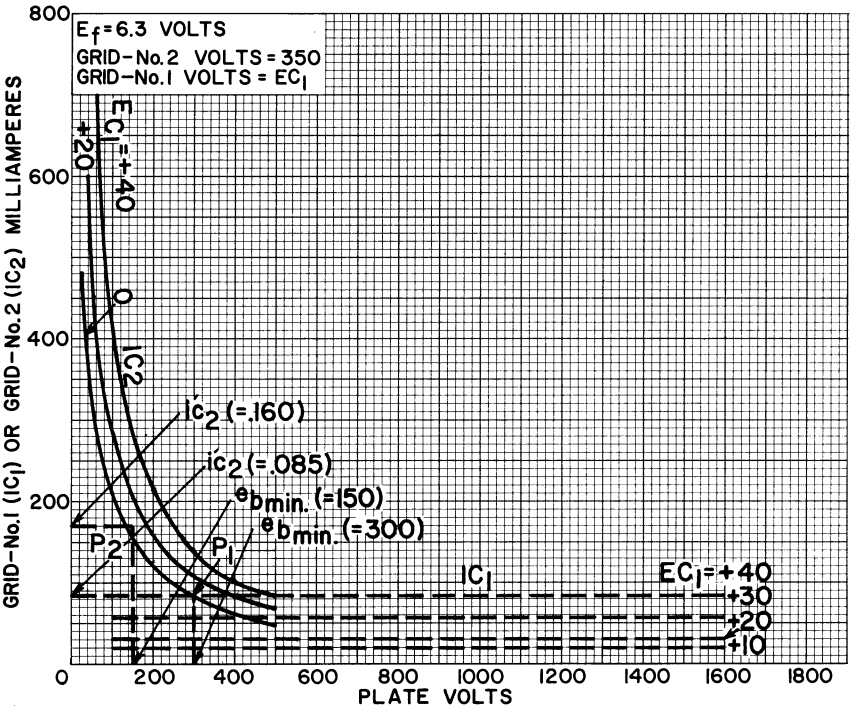

Figure 2: Typical characteristics for type 7094.

characteristics curves, i'_{c2} is 0.160 ampere.

$I_{bms} = 0.570/3 = 0.190$ ampere.

$PD = (0.190/4)\ [2000 + 3\ (150)] =$ 116 watts.

$SI = (350)\ (0.160)/4 = 14$ watts.

$PI = (2000)\ (0.190) = 380$ watts.

All values in steps 3 through 6 are now within maximum ratings, and the calculations may be continued.

(8) $PO = PI - PD = 380 - 116 = 264$ watts.

(9) $I_{bo} = I_{bms}/5 = 0.190/5 = 0.038$ ampere.

(10) E_{c1} can now be determined from the plate-characteristics curves as the control-grid voltage at which the plate voltage is 2000 volts and the plate current is 0.038 ampere; $E_{c1} = -50$ volts.

(11) $E'_g = |E_{c1}| + e_{cm} = 50 + 0 = 50$ volts.

(12) $I_{c2} = i'_{c2}/4 = 0.160/4 = 0.040$ ampere.

(13) $DP = E'_g i'_{c1}/2 = (60)\ (0)/2 = 0.$

A suitable value of driving power can be determined from Table I. For the 7094 in ICAS AB_1 service, a typical value of 4 watts is listed.

(14) $R_p = E_b/1.7\ I_{bms} = 2000/\ (1.7 \times 0.190) = 6200$ ohms.

* * *

Table I shows the maximum ratings and typical operating conditions for several popular RCA tubes in linear rf amplifier service for single-sideband, suppressed-carrier service.

It should be remembered that the typical operating conditions shown by the manufacturer (or calculated by the preceding methods) are only approximate. Minor adjustments are usually made in actual operation by slight variation of the control-grid bias or screen-grid voltage. In linear rf amplifier circuits for single-sideband, suppressed-carrier transmission, it is particularly important to check the actual operating conditions when the transmitter is first set up to assure that linear operation within the maximum tube ratings is being obtained.

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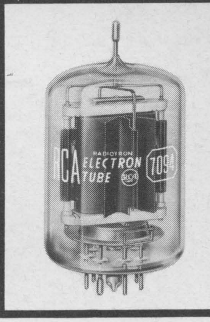

DETERMINATION OF TYPICAL OPERATING CONDITIONS

For RCA Tubes Used as Linear RF Power Amplifiers

Part II

By Claude E. Doner, W3FAL

RCA Electron Tube Division, Lancaster, Pa.

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Now, in this issue, Part II covers the procedure for calculating typical operating conditions for class B operation of triodes or triode-connected tetrodes in a cathode-drive circuit.

Sample calculations are based on published data and curves for the RCA-7094 power tetrode. (The last issue also included a chart listing maximum ratings and typical operating conditions for several widely used RCA power tubes.)

Class B Operation of Triodes Or Triode-Connected Tetrodes (Cathode-Drive Circuit)

Hams who want to operate tubes at conditions other than those given in the published data can calculate typical operating conditions from the maximum ratings and characteristics curves. Follow the procedure enumerated below to figure the typical operating conditions for class B operation of triodes or triode-connected tetrodes in a cathode-drive circuit. This procedure may be adapted to grid-drive service by elimination of step 13 and of the term P_{ft} from steps 14 and 15. (P_{ft} is one of 21 symbols which are defined on page 2.)

(1) Make sure that E_b is within maximum ratings.

(2) Assume a value of I_{bms} approximately

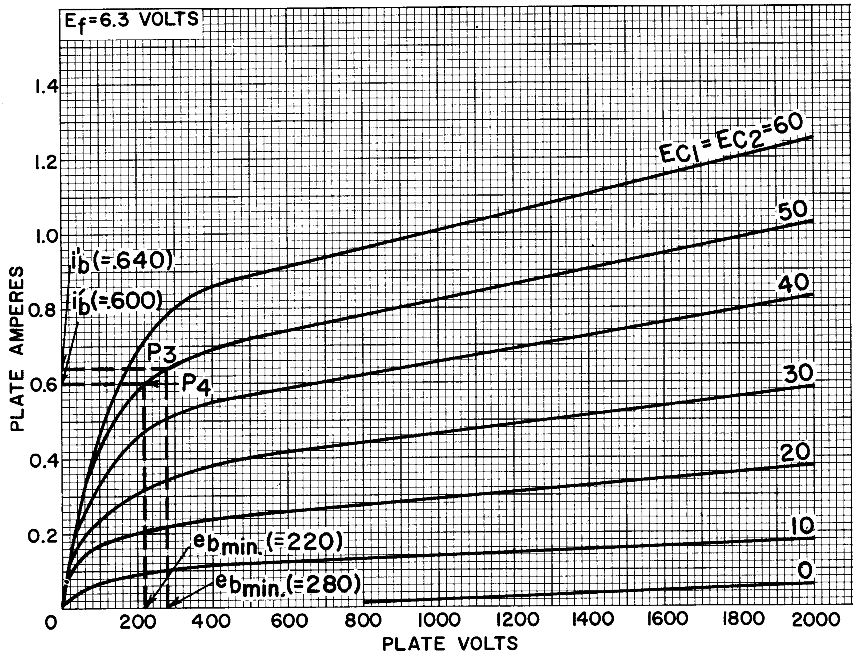

Figure 1: Typical plate characteristics of type 7094 triode connection (grid No. 1 connected to grid No. 2).

- E_b — *DC plate voltage (with respect to cathode)*
- e_{bmin} — *Minimum plate voltage necessary to produce the required peak current (from the characteristics curves)*
- E_{c2} — *DC screen-grid voltage*
- E_{c1} — *DC control-grid voltage*
- e_{cm} — *Maximum control-grid drive voltage needed to obtain the required peak plate current at a given minimum plate voltage*
- E'_g — *Peak value of control-grid voltage swing*
- I_{bms} — *Maximum signal, dc plate current*
- I_{bo} — *Zero-signal, dc plate current*
- i'_b — *Instantaneous peak plate current*
- I_{c1} — *Maximum-signal, dc control-grid current*
- I_{c2} — *Maximum-signal, dc screen-grid current*
- i'_{c1} — *Instantaneous peak control-grid current*
- i'_{c2} — *Instantaneous peak screen-grid current*
- PD — *Plate dissipation at maximum signal*
- PD_o — *Plate dissipation at zero signal*
- PI — *Plate power input at maximum signal*
- PO — *Power output at maximum signal*
- P_{ft} — *Feed-through power at maximum signal (cathode-drive operation)*
- DP — *Driving power at maximum signal*
- SI — *Screen-grid input at maximum signal*
- R_p — *Effective rf plate-load resistance*

equal to 3 (rated maximum PD)/E_b. This value should be within the maximum ratings for the tube. If it is not, use the maximum rated value of I_{bms}.

(3) Calculate I_{bo}: $I_{bo} = I_{bms}/5$.

(4) Calculate PD_o: $PD_o = E_b I_{bo}$. The value of PD_o should not exceed the CCS plate-dissipation rating. If it does, determine I_{bo} as follows: I_{bo} = rated CCS PD/E_b, and use this value instead of the value obtained in step 3.

(5) Determine E_{c1} from the plate-characteristics curves as the control-grid voltage at which the plate voltage is E_b and the plate current is I_{bo}. For zero-bias operation, I_{bo} is the plate current at the point on the curve for zero control-grid voltage at which the plate voltage equals E_b; calculate $PD_o = I_{bo} E_b$. If the value of PD_o exceeds the CCS plate-dissipation rating, a new point must be selected at a lower value of E_b. If the plate-dissipation rating can be met without drastic reduction of E_b, repeat steps 1 and 2 and continue with step 6.

(6) Calculate i'_b: $i'_b = 3\ I_{bms}$.

(7) From the plate-characteristics curves, select a value of e_{bmin} near the knee of the curves at which i'_b can be obtained; record e_{cm} and $i'_{c1} + i'_{c2}$ for this point.

(8) Calculate PD: PD = $(I_{bms}/4)\ (E_b + 3\ e_{bmin})$.

(9) Calculate $I_{c1} + I_{c2}$: $I_{c1} + I_{c2} = (i'_{c1} + i'_{c2})/4$.

(10) Calculate PI: PI – $E_b\ I_{bms}$.

(11) Check the values obtained in steps 8 through 10 to determine whether they are within the maximum ratings for the tube type. If the calculated values exceed the maximum ratings, choose a lower value of I_{bms} and repeat steps 3 through 10.

If all the values are well below maximum

ratings, a higher value of I_{bms} can be chosen in step 2, and steps 3 through 10 repeated to see whether the operation is still within ratings. If so, the latter set of operating conditions can be used to provide slightly more power output.

When values slightly below the maximum ratings are obtained for plate dissipation, control-grid and screen-grid currents, and plate input, the corresponding value of I_{bms} represents the maximum value which can be used at the original plate voltage selected. Lower values of I_{bms}, which provide more conservative operation but less power output, can also be used.

(12) Calculate $E'g$: $E'g = |Ec_1| + e_{cm}$.

(13) Calculate P_{ft}: $P_{ft} = E'_g\, i'_b/4$.

(14) Calculate PO: $PO = (E_b - e_{bmin})\, i'_b/4 + P_{ft}$.

(15) Calculate DP: $DP = E'_g\,(i'_{c1} + i'_{c2})/4 + P_{ft}$. In cathode-drive operation, the driver output need be only slightly greater than the calculated DP because P_{ft} is normally large compared to the rf tube and circuit losses.

(16) Calculate R_p: $R_p = E_b/1.7\, I_{bms}$.

* * *

Example—Here is an example that illustrates the calculation of typical operating conditions for class B triode-connected ICAS operation of the 7094 tetrode in a cathode-drive circuit:

(1) The maximum plate-voltage rating is 2000 volts.

(2) $I_{bms} = 3$ (rated ICAS PD)/E_b = $3(125)/2000 = 0.188$ ampere; this value is within ratings.

(3) $I_{bo} = I_{bms}/5 = 0.188/5 = 0.038$ ampere.

(4) $PD_o = E_b\, I_{bo} = (2000)\,(0.038) =$ 76 watts; this value is within the CCS plate-dissipation rating.

(5) E_{c1} can be determined from the plate-characteristics curves shown in Figure 1 as the grid voltage at which the plate voltage is 2000 volts and the plate current is 0.038 ampere; $E_{c1} = -2$ volts. Because this value is quite close to zero, zero-bias operation may be possible at the same or a slightly lower E_b. When E_b equals 2000 volts on the curve for zero control-grid voltage, I_{bo} is 0.060 ampere.

Recalculate step 4 using this value: $PD_o = (2000)\,(0.060) = 120$ watts.

Because this value exceeds the maximum CCS plate-dissipation rating, a lower value of E_b must be chosen. At the point where E_b is 1750 volts, I_{bo} is 0.050 ampere.

Recalculate step 4: $PD_o = (1750)\,(0.050) = 88$ watts.

This value is within ratings. Recalculate step 2 and continue with step 6.

$I_{bms} = 3(125)/1750 = 0.214$ ampere.

(6) $i'_b = 3\, I_{bms} = 3(0.214) = 0.642$ ampere.

(7) Select a point P3 on knee of one of the curves shown in Figure 1 at which i'_b equals 0.642 ampere. At this point, e_{cm} is + 50 volts and e_{bmin} is 280 volts. From the curves shown in Figure 2, $i'_{c1} + i'_{c2}$ equals 0.520 ampere.

(8) $PD = I_{bms}/4\,(E_b = 3\, e_{bmin}) = 0.214/4\,[1750 + 3\,(280)] = 139$ watts.

(9) $I_{c1} + I_{c2} = (i'_{c1} + i'_{c2})/4 = 0.520/4 = 0.130$ ampere.

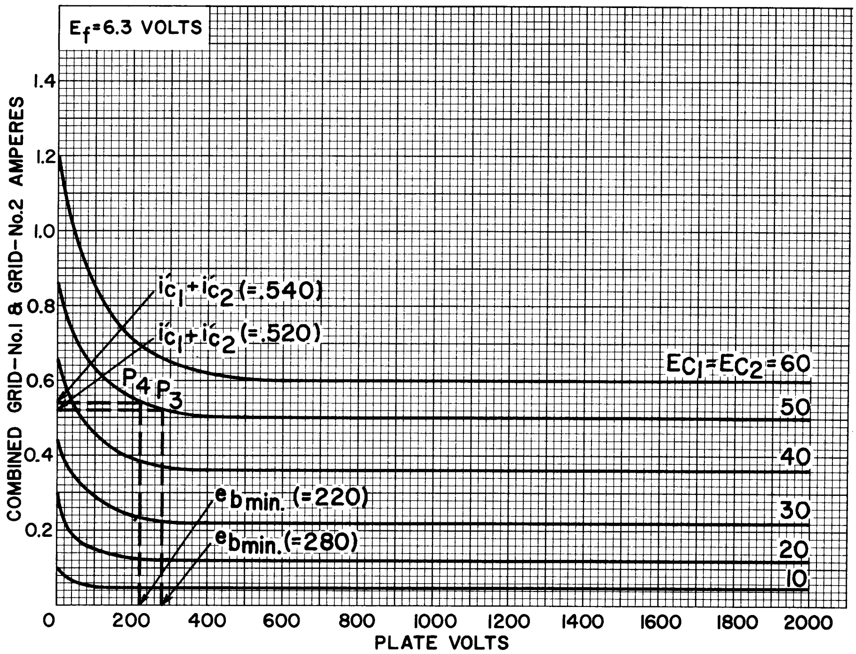

Figure 2: Typical grid characteristics for type 7094 triode connection (grid No. 1 connected to grid No. 2.)

(10) $PI = E_b I_{bms} = (1750)\ (0.214) =$ 375 watts.

(11) Because the value of PD obtained in step 8 is above the maximum ICAS rating, select a lower value of I_{bms} to obtain a lower value of i'_b and e_{bmin}, and recalculate steps 6 through 10.

$I_{bms} = 0.200$ ampere.

$i'_b = 3\ (0.200) = 0.600$ ampere.

At the new point P4, $e_{cm} = +50$ volts, $e_{bmin} = 220$ volts, and $i'_{c1} + i'_{c2} = 0.540$ ampere.

$PD = 0.200/4\ [1750 + 3\ (220)\ ] = 120$ watts.

$I_{c1} + I_{c2} = 0.540/4 = 0.135$ ampere.

$PI = (1750)\ (0.200) = 350$ watts.

All values are now within ratings; therefore, the remainder of the calculations can be completed.

(12) $E'_g = |E_{c1}| + e_{cm} = 0 + 50 = 50$ volts.

(13) $P_{ft} = E'_g\, i'_b/4 = 50\ (0.600)/4 = 7.5$ watts.

(14) $PO = (E_b = e_{bmin})\ i'_b/4 + P_{ft} = (1750 - 220)\ (0.600)/4 + 7.5 = 237$ watts.

(15) $DP = E'_g\ (i'_{c1} + i'_{c2})/4 + P_{ft} = (50)\ (0.540)/4 + 7.5 = 14$ watts.

(16) $R_p = E_b/1.7\ I_{bms} = 1750/(1.7 \times 0.200) = 5100$ ohms.

These values compare reasonably well with the published values.

* * *

Conclusion—Table I (published in the last issue: December, 1960) shows the maximum ratings and typical operating conditions for several popular RCA tubes in linear rf amplifier service for single-sideband, suppressed-carrier service.

It should be remembered that the typical operating conditions shown by the manufacturer (or calculated by the preceding methods) are only approximate. Minor adjustments are usually made in actual operation by slight variation of the control-grid bias or screen-grid voltage. In linear rf amplifier circuits for single-sideband, suppressed-carrier transmission, it is particularly important to check the actual operating conditions when the transmitter is first set up to assure that linear operation within the maximum tube ratings is being obtained.

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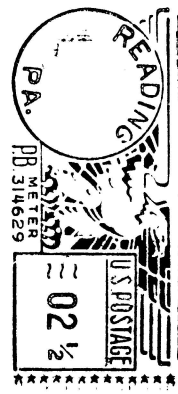


HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. 21, NO. 2

MAY, 1961

NUVISTOR TWO-METER CONVERTER

By R. M. Mendelson, W2OKO

RCA Electron Tube Division, Harrison, N.J.

RCA nuvistor receiving tubes—designed, engineered, and constructed for VHF operation—have opened an entirely new field of amateur radio activity.

Consider the RCA-6CW4, for example. Its wide acceptance as an rf amplifier tube for television fringe areas has proven its superiority over conventional triodes for weak-signal amplification. When used with the latest thimble-size nuvistor, the RCA-7587 tetrode mixer, the overall performance of the 6CW4 as a front-end VHF converter is considerably enhanced.

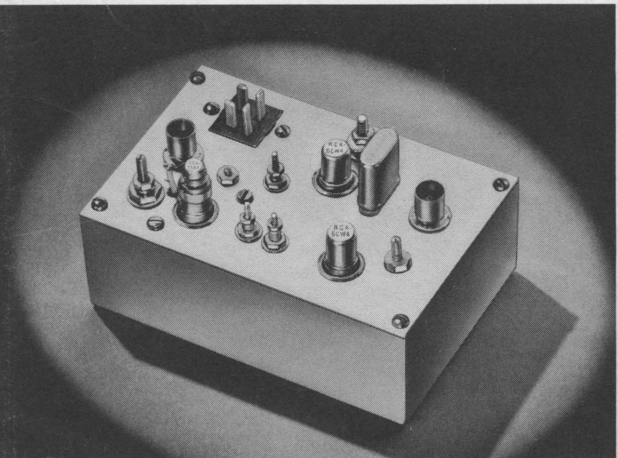
The 7587 has many advantages over its older glass-tube counterparts. In addition to small size, low heater power, rugged construction, and low lead inductance, the nuvistor tetrode has a high transconductance (almost twice that of the nearest glass tube) at a low plate voltage and plate current. It also has reduced input loading because it needs low local-oscillator drive. Because the tube has a high conversion gain, it provides a good output-signal voltage.

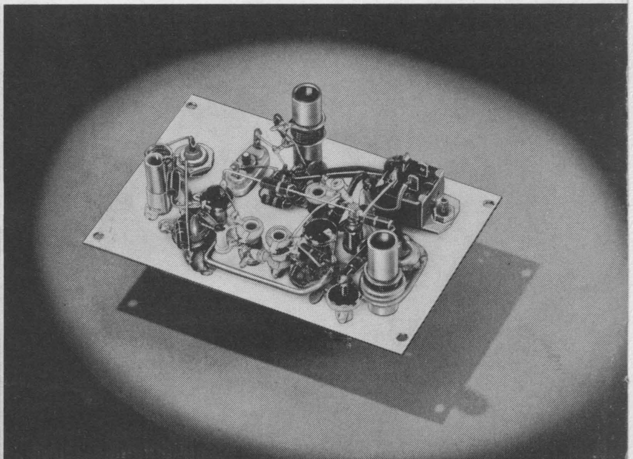
As shown in the schematic for a VHF mixer (Figure 1), the RCA-6CW4 is used as a low-noise rf amplifier followed by an RCA-7587 tetrode mixer. Another 6CW4 is used in a one-stage overtone crystal oscillator. The rf amplifier, an inductance-neutralized stage, is similar to one described in the September, 1960, issue of QST. The mixer and oscillator stages make optimum use of the unique nuvistor characteristics. Power required for the heaters is 410 milliamperes at 6.3 volts; for the B+ voltage, approximately 25 milliamperes at 110 volts.

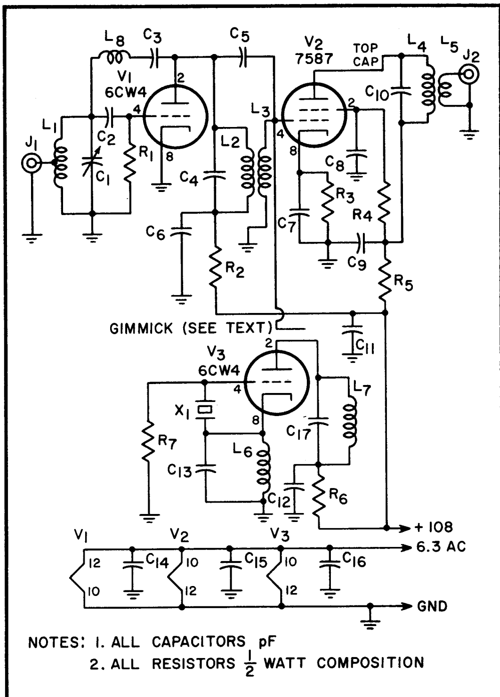
Construction

All coils except the rf-amplifier input coil have been wound on slug-tuned forms to provide neat construction and ease of alignment. Slug tuning eliminates the need for pulling and squeezing neatly wound coils for proper tuning. If the template given in Figure 4 is

Top and bottom view of W2OKO's nuvistor two-meter converter.







C_1—0.5 to 5 pf tubular trimmer (Erie type 532A or equiv.)
C_2, C_3, C_{11}, C_{12}, C_{14}, C_{15}, C_{16}—500 pf ceramic disc (Centralab type DD 501 or equiv.)
C_4, C_{17}—3.3 pf ceramic tubular (Centralab type TCZ 3R3 or equiv.)
C_5—2.2 pf ceramic tubular (Centralab type TCZ 2R2 or equiv.)
C_6, C_7, C_8, C_9—500 pf silver button (Erie type 370 CB-501K or equiv.)
C_{10}, C_{13}—30 pf ceramic (Centralab type DD 300 or equiv.)
J_1, J_2—Coax jack type BNC
L_1—5 turns No. 16 bare wire, ¼-inch diameter, spaced wire diameter, tap 2 turns up or best noise figure
L_2—4 turns No. 26 enamelled wire, ¼-inch diameter, close wound on slug-tuned form (CTC-PLST or equiv.)
L_3—4 turns No. 26 enamelled wire, ¼-inch diameter, close wound on slug-tuned form (CTC-PLST or equiv.)
L_4—11 turns No. 26 enamelled wire, ⅜-inch diameter, close wound on slug-tuned form (CTC-LS3 or equiv.)
L_5—3 turns insulated wire, close wound link
L_6—5 turns No. 26 enamelled wire, ⅜-inch diameter, close wound on slug-tuned form (CTC-LS3 or equiv.)
L_7—7 turns No. 26 enamelled wire, ¼-inch diameter, close wound on slug-tuned form (CTC-PLST or equiv.)
L_8—25 turns No. 30 enamelled wire, wound on 1-megohm ½-watt resistor, approximately 5/16-inch long; adjust for neutralization (see text)
R_1—47,000 ohm, ½ watt
R_2—6800 ohm, ½ watt
R_3—68 ohm, ½ watt
R_4—18,000 ohm, ½ watt
R_5—470 ohm, ½ watt
R_6—27,000 ohm, ½ watt
R_7—100,000 ohm, ½ watt
Miscellaneous—1 standoff insulator; 1 socket (Jones type P304AB or equiv.); 1 crystal 39.33 megacycle overtone (International Crystal Co. type FA5 or equiv.) for output 26-30 Mc; 3 nuvistor sockets (Cinch No. 133 65 10 0.011)

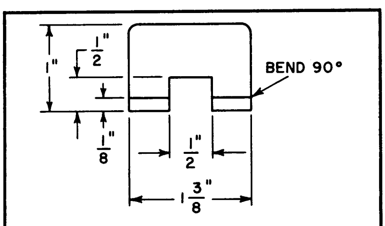
Figure 1: Schematic diagram and parts list.

used for layout, the coils can be mounted in the same position as on the original model, and unwanted feedbacks and intercouplings will be eliminated. The oscillator coil is coupled to the mixer input by a lead wire from the grid end of the mixer coil to an unused lug on the plate end of the oscillator coil. No further coupling is needed.

Because of their small size, nuvistor sockets are clamped (rather than bolted) to the chassis by bending two lugs on the socket. After the chassis hole is drilled, two notches are hand-filed (see Figure 4) to insure a tight fit of the socket to the chassis. For grounding, both socket lugs are soldered to the chassis, which should be a copper or brass plate. All ground connections for each socket should be made to the socket lugs, except in the case of the rf-amplifier, which uses the rf shield as the ground return. This rf shield for the amplifier tube (shown in Figure 2) is a thin piece of brass or copper soldered to pins 8 and 10 of the socket and to the chassis. As in all VHF construction, good grounds are essential. Connection to the top cap (of the tetrode) is best made with a piece of piano wire looped into a tight-fitting one-turn coil.

The converter described in this article was built for use at an if output frequency of 26 to 30 megacycles. For lower if outputs, only the crystal and the if output coil frequencies need be changed. If operation at 14 to 18 megacycles is desired, a crystal frequency of 43.3 megacycles should be used. No changes

Figure 2: Base shield.



are necessary in the oscillator coil. The output coil requires approximately 22 turns to tune to 14 megacycles.

Alignment

Alignment of this two-meter converter is simple. You need only a grid-dip meter and a receiver having an S meter. If available, sweep generators and noise sources can be used for greater accuracy in alignment.

First, use the grid-dip meter to set all coils to the correct frequencies: L_1, L_2, and L_3 to 146 megacycles, L_4 to 28 megacycles, L_6 to 40 megacycles, and L_7 to 118 megacycles.

Next, connect the antenna and receiver to the converter and apply power. The high-voltage input should not exceed 125 volts, the plate-voltage maximum rating for the 6CW4 and the 7587.

Check that the wiring is correct by comparing the voltages with those in the following table. All voltages are with respect to ground and may vary by 20%.

Voltage	*Tube Type* V_1 *6CW4*	V_2 *7587*	V_3 *6CW4*	
Plate to ground	65	103	50	volts
Screen grid to ground	—	50	—	volts
Control grid to ground	0	0	0	volts
Cathode to ground	0	–0.7	0	volts

If the grid-dip meter adjustments are made correctly, signals can be heard on the two-meter band. If no signals are heard, the oscillator should be checked by removing the crystal from the socket. With the crystal removed, the background noise from the receiver should fall off. A slight readjustment of L_6 may be necessary to start up the oscillation. L_7 should be peaked for maximum oscillator output.

Tune in a signal at about 145 megacycles and tune L_2 for maximum S-meter reading. Repeat at 147 megacycles and tune L_3. Find a signal near the middle of the band and tune $L_1 - C_1$. This tuning is very broad.

The rf amplifier is most easily neutralized by first opening its heater lead. Adjust L_8 by starting with a few extra turns and removing one turn at a time to find the point of minimum feed-through of a strong signal when the other tubes are operating. This adjustment is not very critical.

Conclusion—The fine performance of this easily constructed nuvistor converter will surprise any ham who thought that a good converter was hard to build or required elaborate alignment equipment.

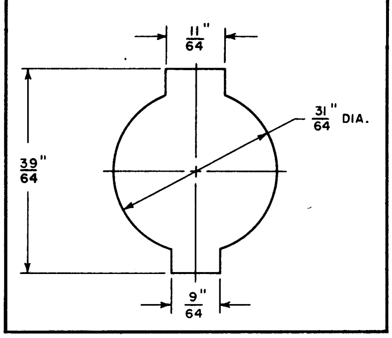
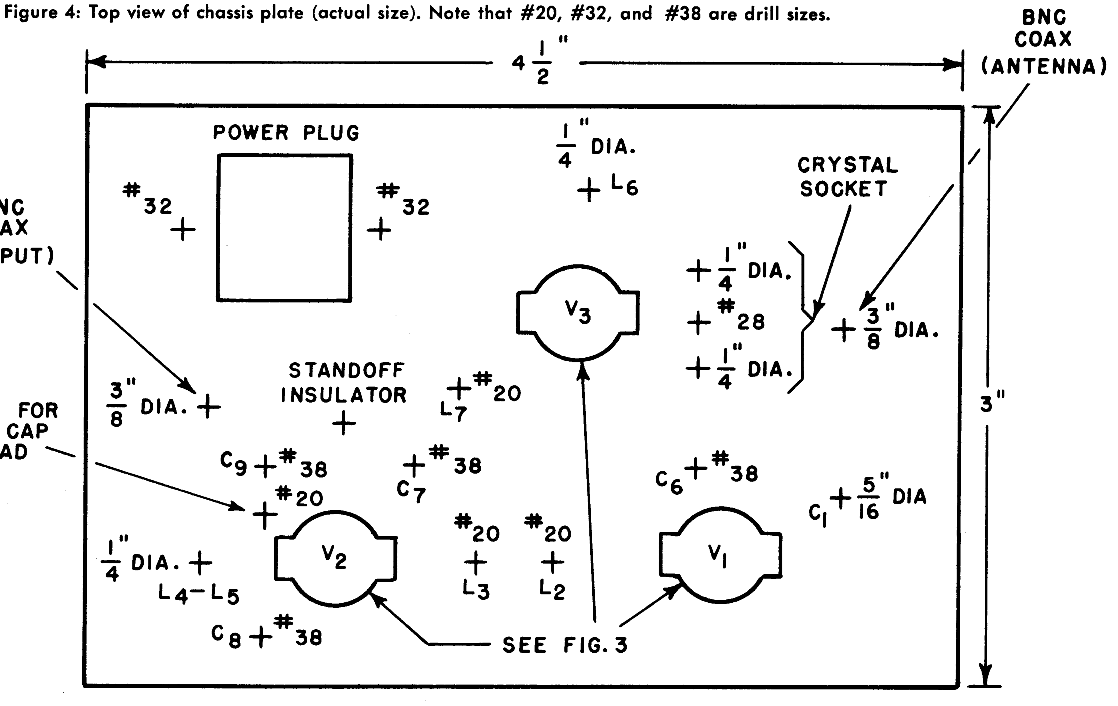


Figure 3: Nuvistor socket hole.

Figure 4: Top view of chassis plate (actual size). Note that #20, #32, and #38 are drill sizes.



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HAM TIPS

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NUVISTOR PREAMPLIFIER

For Amateur Receivers

By M. Adams, WA2ELL, and P. Boivin, Jr., K2SKK

RCA Electron Tube Division, Harrison, N. J.

A comment frequently heard on the amateur bands is, "This receiver is fine on 80 up through 20 meters, but on 10 and 15 it seems to lose sensitivity." The problem is a common one, especially with older, general-coverage communications receivers which tune from 0.55 to 35 megacycles in four bands. Because the 10-meter band is near the upper limit of this tuning range, sensitivity often drops off as a result of stray capacitance and a less than optimum LC ratio for this frequency.

One solution to the problem is a ham-band-only receiver optimized for each band. However, on some older models of this type, 10-meter sensitivity still is not satisfactory. All-band preselectors are also available, but these are expensive, elaborate, and bulky; also the extra boost is usually not needed on the lower frequencies. This article describes a preamplifier that adds 25 to 35 db gain ahead of the receiver on the desired band and can be built for less than $15 from readily available parts.

TABLE I: PERFORMANCE DATA

Band—meters	Frequency—Mc	Gain—db
15	21.0 21.5	30 30
10	28.0 29.0 30.0	27 29 26
6	50.0 51.5	17 16

Design Features

The unit (shown below) is built around a pair of RCA-6CW4 nuvistor triodes. These tiny high-mu triodes, designed for use as

Top view of authors' nuvistor preamplifier designed around two RCA-6CW4's.

TV-tuner rf amplifiers, work exceptionally well at 30 Mc. The preamplifier provides ample gain ahead of the receiver and improves the signal-to-noise ratio. The resulting overall sensitivity is equal to that of many higher-priced receivers. Gain measurements for the unit are shown in Table I.

As an example of what can be expected from this preamplifier, a 10-meter unit was

TABLE II: COIL DATA

Band—meters	Coil	C_1	C_2	Links
15	L_1—18 turns #32 enameled wire on ¼-inch slug-tuned form L_2—18 turns #32 enameled wire on ¼-inch slug-tuned form	15 $\mu\mu f$	15 $\mu\mu f$	1½ T
10	L_1—18 turns #32 enameled wire on ¼-inch slug-tuned form L_2—18 turns #32 enameled wire on ¼-inch slug-tuned form	5 $\mu\mu f$	5 $\mu\mu t$	1½ T
6	*L_1—10 turns #32 enameled wire on ¼-inch slug-tuned form *L_2—10 turns #32 enameled wire on ¼-inch slug-tuned form	5 $\mu\mu f$	6.8 $\mu\mu f$	1½ T

Note: All coils Cambion CTC DLSM 10 Mc.

*Same 10 Mc coil as above with 8 turns removed.

used ahead of a 10-year-old, general-coverage, single-conversion receiver in the $200 class. At 29 Mc, the receiver alone has a 10-db signal-to-noise ratio at an input of 20 microvolts. With the preamplifier ahead of the receiver, a 10-db signal-to-noise ratio is obtained at a 2.5-microvolt input. This improvement represents a sensitivity increase of 8 times at an equivalent signal-to-noise ratio. The preamplifier output impedance is 75 ohms, while the receiver input impedance may vary from 100 to 300 ohms depending on the design of the input network. If the unit is properly matched to the receiver, sensitivity can be improved even more.

An improvement in signal-to-noise ratio results from the lower noise factor of the nuvistor circuit as compared to that of older pentode amplifier designs. A noise figure of 4.5 db was measured for the nuvistor preamplifier by means of the noise-generator method. With the added gain of the preamplifier, the receiver front-end contributes negligible noise to the system. The noise factor of the preamplifier could be improved an additional 1 db by precise adjustment of the input link and proper tuning. However, the simplicity of alignment would be lost, and the resulting improvement in performance would be difficult to detect in actual use.

TABLE III: ALIGNMENT DATA

Band	Tune L_1 to	Tune L_2 to
15 M	21.25 Mc	21.25 Mc
10 M	32.00 Mc	29.50 Mc
6 M	51.00 Mc	50.00 Mc

Construction and Alignment

Similar to the cascode amplifier in the ARRL Amateur Handbook, the circuit, shown in Figure 1, is used in many TV tuners. It has been reduced to its basic form to simplify construction and alignment. As indicated in Table II, a 1½-turn link around the hot end of L_1 matches a 75-ohm coaxial transmission line to the high-impedance input of a conventional grounded-cathode amplifier V_1. The output of V_1 is fed to the cathode of V_2, a grounded-grid amplifier in which the output appears across plate coil L_2. Another link around L_2 couples the output signal to a 75-ohm line to the receiver. Even though this type of amplifier is inherently stable, ample decoupling and bypassing have been included in the design. V_1 and V_2 are operated in a stacked arrangement in series with the B+ supply. Proper bias for V_2 is maintained by tying the grid back to the plate of V_1 through R_3. Because V_2 receives a larger signal than V_1, additional bias for V_2 is obtained across R_2.

All the parts required are available through local RCA tube distributors, including the 6CW4 nuvistor triodes and sockets. Although lower-cost tube types may be used for V_1 and V_2, only the 6CW4 provides all the advantages of small size, low power drain, and excellent performance. In addition, two separate tubes provide better isolation and a more stable amplifier.

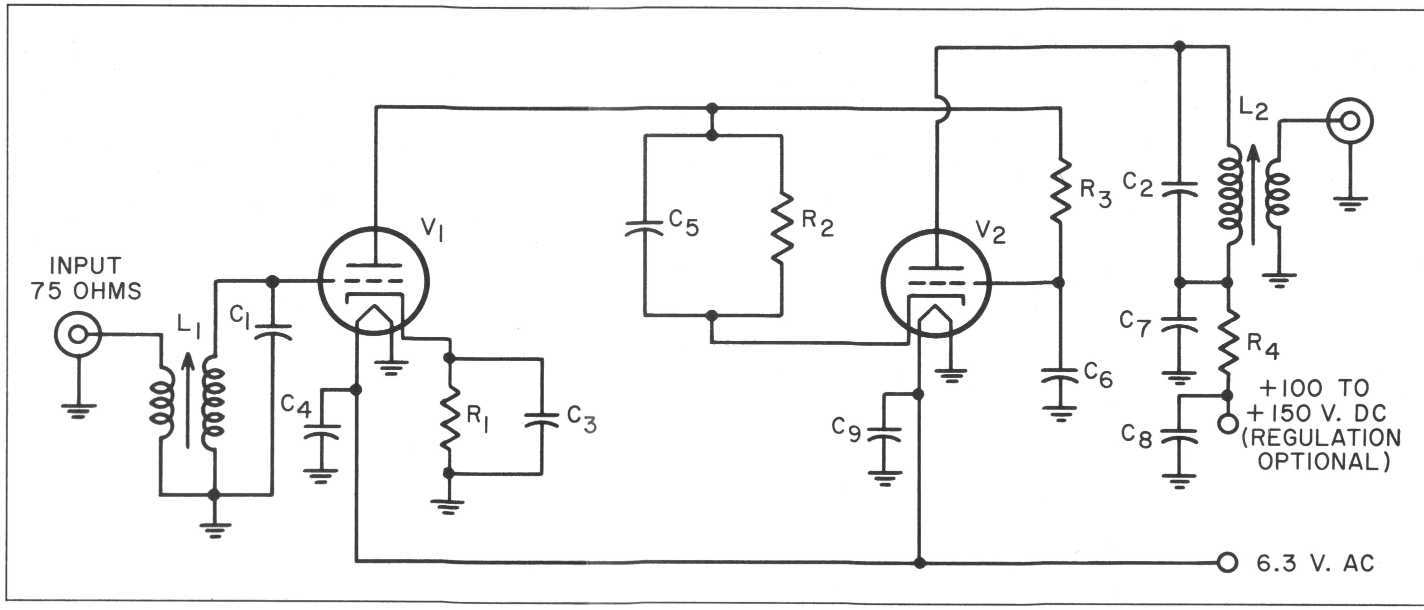
A 1½- by 2- by 4-inch aluminum minibox, shown in Figure 2, provides more than enough room for construction. As in any circuit at this frequency, leads should be kept short and the input isolated from the output.

Although the circuit is not especially critical, a shield has been placed between the two triodes for maximum isolation. Oscillation, which should not occur if the input and output are connected to the proper impedances, may be encountered if the antenna is not connected.

The original 10-meter unit was designed to use high-Q tuned circuits to obtain a flat-topped response over the band, and required careful tuning with the aid of a sweep generator and 'scope to obtain the desired response. The unit described in this article uses lower-Q tuned circuits which have a broader response. This arrangement is not only easier to align initially, but is also less sensitive to changes in supply voltage and loading. Alignment data for three bands are listed in Table III. The difference in gain over the band is not sufficient to degrade performance.

A grid-dip oscillator may be used to pre-set the coils at the correct frequency. For 15 meters, adjust L_1 and L_2 to a maximum indicated signal on the S-meter of the receiver with the preamplifier connected and a 21.25 Mc input signal. For 10 and 6 meters, adjust L_1 and L_2 with a grid-dip oscillator to the frequencies indicated in Table III, with no power connected to the preamplifier. The grid-dipper frequency should be checked against a reliable standard to insure correct alignment. The preamplifier cannot be tuned for 10 and 6 meters with a grid-dip oscillator if the heaters are on because grid current in V_1, due to the signal from the dip oscillator, will result in a false indication or no dip at all. If a sweep generator and 'scope are available, alignment is no problem. Simply tune the coils so that the edges of the band fall at the –3 db points on the response curve. The links should not have to be adjusted during alignment.

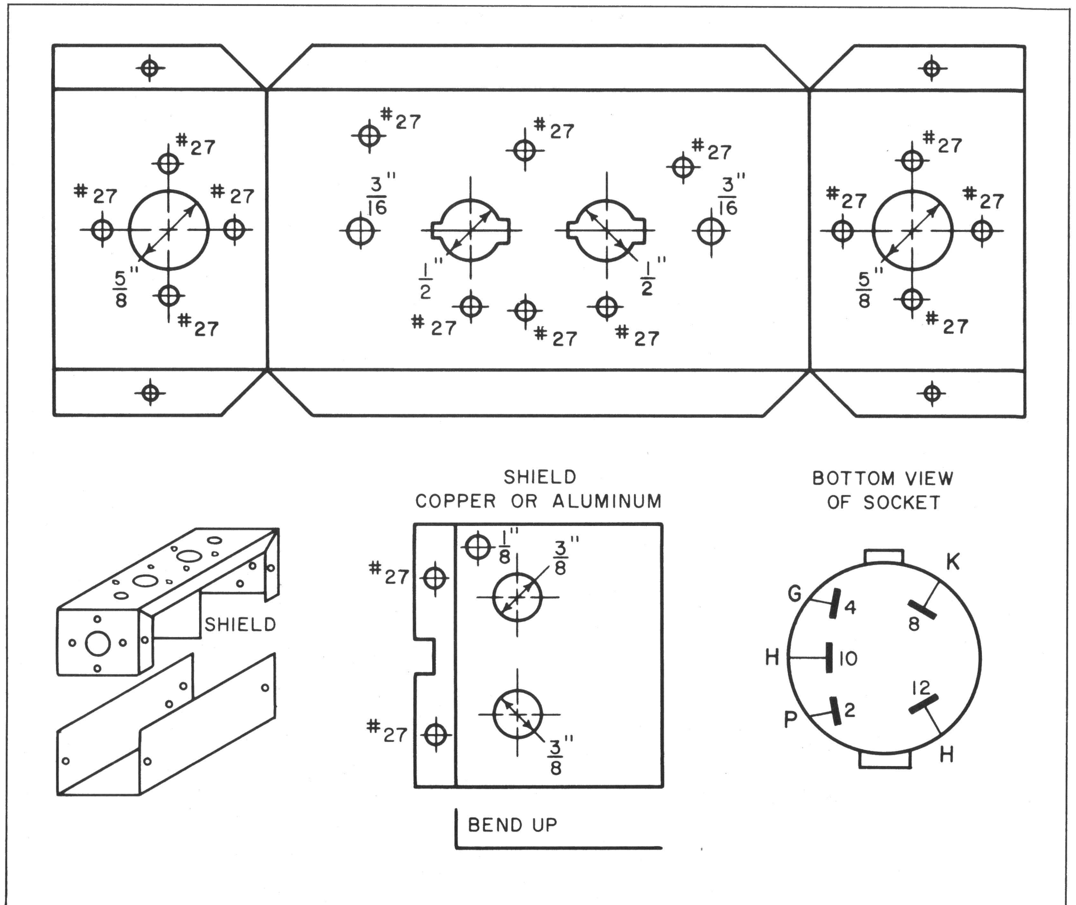
The preamplifier may be mounted inside the receiver cabinet, but should be more convenient to disconnect if mounted on the back near the antenna terminal. The maximum length of coaxial cable between the receiver and the preamplifier should not exceed 12 inches. The small power requirements (5 milliamperes at 150 volts and 0.26 amperes at 6.3 volts) may be obtained from the receiver through the accessory plug. The unit described uses 75-ohm coaxial connectors for easy changeover to bands where the preamplifier is not needed. If a balanced antenna system is used, terminal strips for the twin-lead may be used instead of coaxial connectors. In this case, the input link around L_1 would not be grounded. If 300-ohm twin-line is used for the input, one extra turn should be added to the input link to match the line.



C_1, C_2—see coil data, Table II
C_3, C_4, C_5, C_6, C_7, C_8, C_9—0.001 μf, ceramic, 500 v
L_1, L_2—see coil data, Table II (Link: 1½ turns #32 enameled wire on form over other turns)
R_1, R_2—100 ohms, ½ w, carbon
R_3—470,000 ohms, ½ w, carbon
R_4—1,000 ohms, ½ w, carbon
V_1, V_2—6CW4

Figure 1: Schematic diagram and parts list.

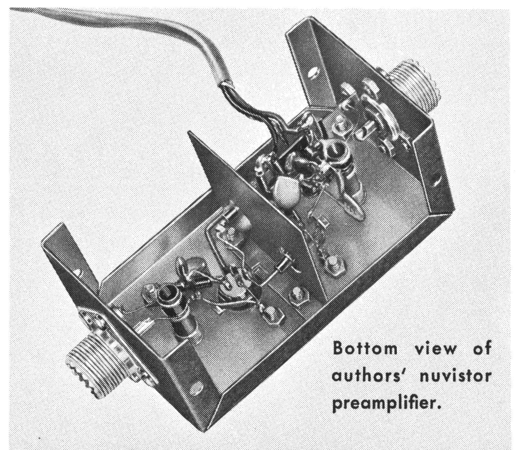
Figure 2: As stated in the text, a 1½- by 2- by 4-inch minibox provides more than enough room for construction.



When to Use

The nuvistor preamplifier is not intended to improve the image rejection of a single conversion receiver. Because response is intentionally made broad to eliminate tuning during operation, images will be present whether the unit is used or not. The increased sensitivity of the receiver due to the nuvistor unit will be apparent from the rise in background noise level. In addition, signals that were previously about equal to the background noise in strength will be 3 or 4 S-units above the noise with the preamplifier connected, due to the improvement in signal-to-noise ratio in the front-end. The greatest improvement will be noticed in receivers having poor sensitivity initially. Little advantage is gained in receivers which have 1.5 to 3 microvolt sensitivity and a good signal-to-noise ratio. If it is desired to use this circuit on 6 meters, the design can be incorporated in a crystal-controlled or tunable-type converter. This arrangement would eliminate tracking problems because the rf section would not have to be tuned after initial alignment.

The nuvistor preamplifier has been designed for best performance consistent with simplicity and ease of construction and alignment. If you have not been hearing those signals on ten, here is the opportunity to obtain top performance from your receiver with a minimum investment.



Bottom view of authors' nuvistor preamplifier.

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Check the chart for the types that fit your dc power requirements. Then order direct from your RCA industrial-tube distributor. For technical data on any of these types, write: Commercial Engineering, RCA Electron Tube Division, Harrison, N. J.

RCA Rectifier Tubes—with the new N-85-R Filament
(Based on use of 2 tubes in full-wave circuit, choke-input filter)

Type	Name	Max. Transf. Sec. Volts (RMS)	Approx. DC Output Volts	Max. DC Output Amperes
RCA-3B28*	Half-wave, gas	3500 1700	3200 1600	0.5 1.0
RCA-816	Half-wave, mercury-vapor	2600	2400	0.25
RCA-866A	Half-wave, mercury-vapor	3500 800	3200 800	0.5 1.0
RCA-872A	Half-wave, mercury-vapor	3500	3200	2.5
RCA-8008†	Half-wave, mercury-vapor	3500	3200	2.5

*For low noise-level applications. †Same as RCA-872A, but has long-pin base.

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Harvey Slovik, Editor

HAM TIPS
A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION
VOL. 21, NO. 4 DECEMBER, 1961

Transistors As RF Power Amplifiers

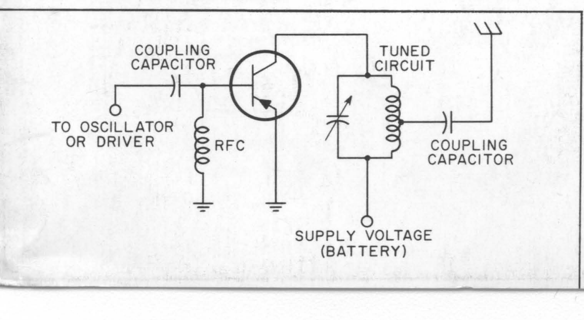
By J. B. Fisher, WA2CMR/6
Field Sales Engineering
RCA Semiconductor and Materials Division
Somerville, N. J.

Recent advances, particularly the advent of the high-frequency "mesa" device and the use of silicon, have brought transistors to the point where they may usefully serve as drivers for high-power-output tubes, or as power stages themselves. To effect a smooth transition from tube to transistor circuit design, however, the experimenting amateur should be aware of the major differences between the two devices. Some of the important considerations for rf power amplifier design are discussed below.

Class of Operation

The transistor is a natural class C amplifier because the emitter-base contact potential must be overcome before collector current will flow. A transistor connected as shown in Figure 1 is automatically biased in the class C region. As shown by the curves of Figure 2, a positive voltage of 0.3 volt for germanium types or 0.6 volt for silicon types must be applied to the base before collector current starts to flow.

Figure 1: Transistor connected as shown is automatically biased in class C region.



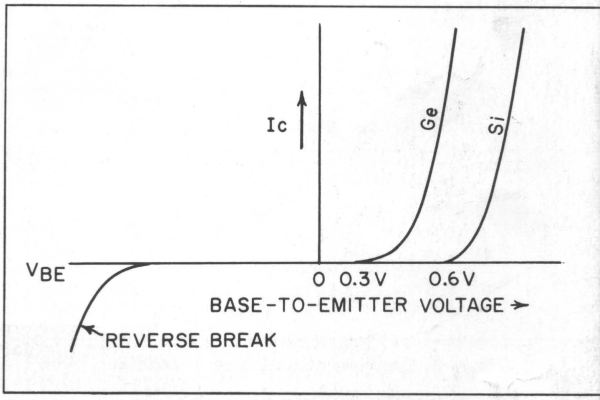


Figure 2: Before collector current will flow, a positive voltage of 0.3 volt or 0.6 volt must be respectively applied to base of germanium or silicon transistor types.

For class B operation, the transistor is forward-biased to the point where collector current just begins to flow. For class A or linear operation, additional forward bias is applied until the desired collector current is drawn.

The circuit for class A or class B operation is shown in Figure 3. The emitter resistance R_3 helps to stabilize the transistor and reduces the possibility of "thermal runaway" in the event of overheating.

"Base-leak" bias may be developed as shown in Figure 4. As base current is drawn, capacitor C charges to the voltage developed across R. If the time constant of RC is long, as compared to one cycle of the transmitted frequency, the charge is retained for this

time. This procedure requires additional driving power to the transistor, however, and does not appreciably increase efficiency.

Care must be taken to insure that the base is not driven too far in the reverse direction. Such "overdriving" could damage the transistor or cause loading of the preceding stage.

Matching

For maximum power output and gain, both the input and output of a transistor circuit should be matched. This procedure differs from tube-circuit design, in which the grid input is usually considered as a high impedance and no attempt is made to match into it.

The input impedance of grounded-emitter stages decreases with increasing power out-

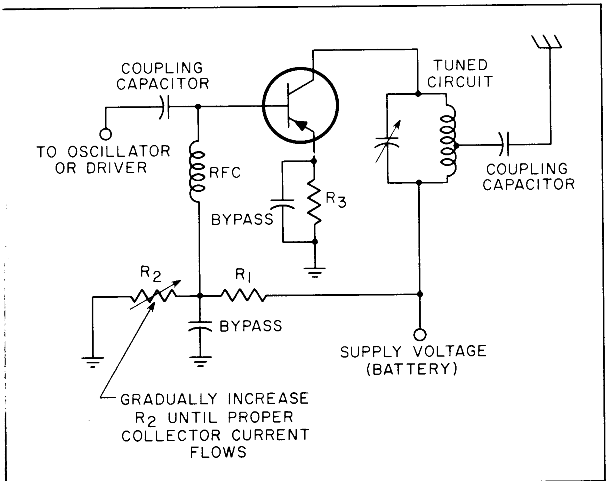


Figure 3: Schematic of class A or B amplifier.

put and is lowest for high-power transistors. Typically, this impedance ranges from 1,000 ohms in the milliwatt region to about 5 ohms for power of 1 watt or more. Grounded-base input impedance is always low, usually in the range from 100 ohms down to about 5 ohms.

Output or collector impedance R_{out} is best obtained from the power required P_{out} and the supply voltage E, as follows:

$$R_{out} = \frac{E^2}{2\,P_{out}}$$

This equation is not exact, but it does provide an approximate figure for design purposes. The output is always capacitive. This capacitance is generally designated by the manufacturer as C_{ob}. The input is usually capacitive at frequencies below 50 megacycles, but may become inductive at higher frequencies.

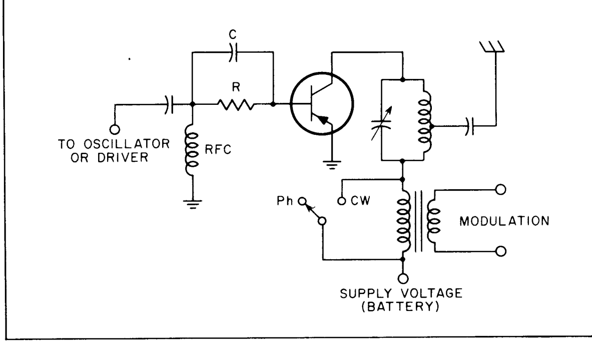


Figure 4: "Base-leak" bias and collector modulation.

[Detailed information on matching is given in the "RCA Silicon VHF Transistors Application Guide" (1CE-228). You can obtain this publication from your local RCA semiconductor distributor. It is also available for 50¢ from Commercial Engineering, RCA Semiconductor and Materials Division, Somerville, N. J.]

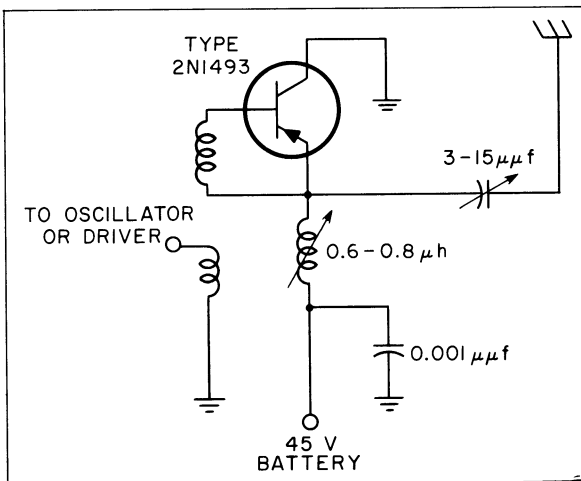
Efficiency

If a transistor is operated well below its alpha cutoff frequency (the frequency at which the forward current gain is 0.707 times its low-frequency value), the theoretical maximum efficiencies for its class of operation can nearly be achieved. For example, the circuit shown in Figure 5 has provided better than 90% efficiency at 50 megacycles with an output of 1 watt. Efficiencies close to 75% can be obtained in class B stages, and nearly 50% in well-designed class A stages.

Neutralization

The greatest similarity between tubes and transistors is in the area of neutralization. The feedback capacitance, sometimes referred to as $C_{b'c}$, is equivalent to grid-plate capacitance in tubes. This capacitance is the major cause of self-oscillation within the transistor.

Figure 5: Schematic of class C, grounded collector, common emitter amplifier.



If the transistor is operated in the common-emitter configuration, this capacitance feeds back a small portion of the collector signal to the base. If this signal is sufficient to overcome base losses, the unit will oscillate. This situation is equivalent to that observed in grounded-cathode operation of triodes. In well-shielded radio-frequency amplifiers, it should be possible to operate the transistor at frequencies up to one-third to one-half its alpha cutoff frequency before neutralization is required.

The common-base configuration, like grounded-grid tube operation, is less subject to self-oscillation because the phase shift between input and output is minimized. At frequencies close to alpha cutoff, however, even this configuration should be neutralized.

Neutralization is accomplished by cancelling out the effects of $C_{b'c}$. Typical neutralization circuits are shown in Figure 6. If the transistor is operated class A, C_n may be adjusted by applying the drive to the output tank, with dc voltages on, and tuning for minimum rf at the input tank. For class C

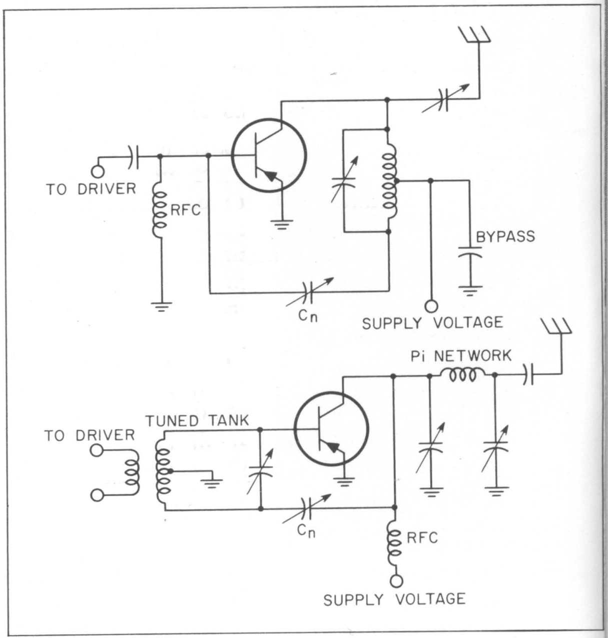


Figure 6: Typical neutralization circuits.

NEW RCA-6DS4 NUVISTOR TRIODE

Improves Two-Meter Converter

By R. M. Mendelson, W2OKO
RCA Electron Tube Division, Harrison, N. J.

Crystal-controlled VHF converters are usually designed for low noise and maximum sensitivity to improve reception of weak signals. For this reason, no provision is made for adjusting the gain of the rf amplifier.

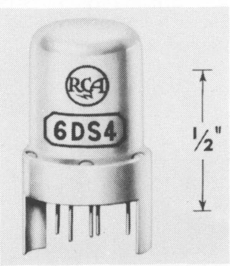
The nuvistor two-meter converter described in HAM TIPS (May, 1961) was so designed, and the RCA-6CW4 triode amplifier was operated "wide open" at all times. With only weak signals present, this arrangement is good. However, strong local signals can cause loading of the converter and crossmodulation.

Crossmodulation can be reduced by the use of automatic gain control on the 6CW4. The newly announced RCA-6DS4 nuvistor triode, however, is much better suited for this application because of its added feature of semiremote cutoff. Because the agc voltage in a communications receiver is not developed until a reasonably strong signal is received, the converter still has maximum sensitivity for weak signal reception.

Circuit Changes

Modification of the original converter is very simple. The new RCA-6DS4 is substituted in the same socket for the RCA-6CW4. One resistor and two capacitors are added.

As stated in the text under "Circuit Changes," to modify W2OKO's original two-meter converter, substitute an RCA-6DS4 nuvistor triode (with semiremote-cutoff characteristic) in the same socket for the RCA-6CW4 nuvistor triode, and add one resistor and two capacitors.



operation, C_n is made approximately equal to $C_{b'c}$, and is then adjusted for best stability of the amplifier with drive.

Heat Transfer

Heat transfer is an important problem in transistor-circuit design, although it is seldom encountered with tubes. Some means should be employed to remove heat from the transistor, especially when its maximum collector dissipation is approached. Heat transfer may be accomplished by solidly attaching or mounting the transistor case to the chassis or heat radiator. If the collector is internally tied to the case, the circuit shown in Figure 5 may be used. In this circuit, the collector is at rf and dc ground potential, although the transistor is operating in the common-emitter configuration.

Modulation

Modulation may be applied to the collector, base, or emitter of a transistor, as it may be applied to the plate, grid, or cathode of a tube. The efficiencies and percentages of modulation available from each type are very similar to those available in tubes. Collector modulation is shown in Figure 4.

Power Output

The amount of power available from a transistorized transmitter is determined by the type of transistor used. There are some low-cost germanium power transistors available with reasonably high alpha cutoff (about 7.5 megacycles) that should work well on 80 meters. With a pair of these (e.g., 2N1905's at an optional list price of about $6.00 apiece), a well-designed circuit will develop approximately 15 watts at 80 meters directly from a 12-volt storage battery. A new type now in development will put out 18 watts on 10 meters and 10 watts on 6 meters. RCA also has developmental types that will produce the maximum legal limit of 1 kilowatt on 80 meters. For the present, these types are limited in distribution and are relatively high in cost; but the amateur can look forward to their general availability in the not-too-distant future.

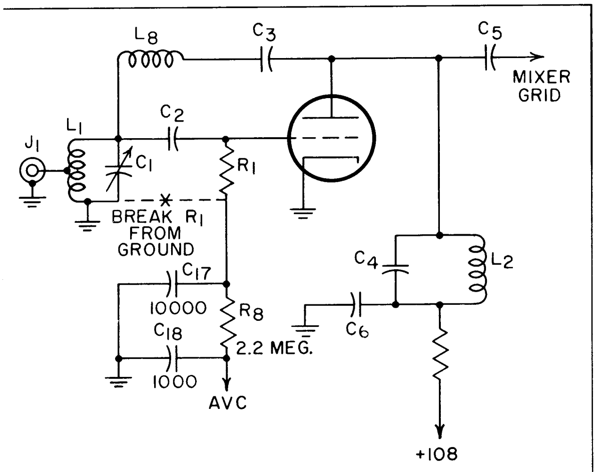


Figure 1: Modification for AVC. (Refer to the May, 1961, issue of HAM TIPS for complete schematic diagram and parts list for W2OKO's nuvistor two-meter converter.)

R_8—2.2 megohms, ½ watt

C_{17}—10,000 pf ceramic disc (Centralab type DD 103 or equivalent)

C_{18}—1,000 pf ceramic disc (Centralab type DD 102 or equivalent)

The agc voltage is obtained from the communications receiver with which the converter operates.

Figure 1 shows the modification of the grid circuit of the rf amplifier. The original grid resistor, R_1, is lifted from ground and rewired through the new R_8 to the spare contact on the Jones socket. C_{17} and R_8 are added as close to R_1 as possible, and C_{18} is added at the Jones socket.

The source of the agc voltage in the communications receiver is easily found by studying the receiver schematic and locating the agc line in the chassis wiring. The agc voltage should vary from zero at no signal to about 8 to 10 volts negative at maximum signal.

One word of caution is advisable. Some communications receivers use a fixed bias between grid and ground for the rf and if stages. If this bias is applied through the receiver agc circuit, it is always present. Thus, it would also be applied continuously to the converter and would greatly reduce its sensitivity. The receiver to be used must have zero voltage on the agc line in the absence of signals.

The effect of this simple circuit addition makes the change very worthwhile, especially in areas of strong signal reception.

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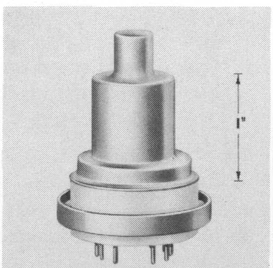
		CCS	ICAS					
5763	CW AM	12	13.5	17 15	350 300	50	175	6.0 (H)
6417	Same as RCA-5763, except for heater voltage							12.6 (H)
2E26	CW SSB AM	10	13.5	40 37.5 27	600 500 500	125	175	6.3 (H)
2E24	Same as RCA-2E26, but has quick-heating filament							6.3 (F)
6893	Same as RCA-2E26, except for heater voltage							12.6 (H)
832A*	CW AM	15	—	50** 36**	750 600	200	250	6.3▲ (H) 12.6● (H)
807	CW SSB AM	25	30	75 90 60	750 750 600	60	125	6.3 (H)
6524*	CW SSB AM	20	25	85** 85** 55**	600 600 500	100	470	6.3 (H)
6850*	Same as RCA-6524, except for heater voltage							12.6 (H)
4604	CW	—	25	90	750	60	175	6.3 (F) quick-heating
6146	CW SSB AM	20	25	90 85 67.5	750 750 600	60	175	6.3 (H)
6883	Same as RCA-6146, except for heater voltage							12.6 (H)
7203 / 4CX250B	CW SSB AM	250	—	500 500 300	2000 2000 1500	500	—	6.0 (H)
813	CW SSB AM	100	125	500 450 400	2250 2500 2000	30	120	10 (F)
8072	CW SSB	100†	—	660 990§	2200 2200	500	500	12 to 15 (H)
8121	CW SSB	150	—	660 990§	2200 2200	500	500	13.5 (H)
8122	CW SSB	400	—	660 990§	2200 2200	500	500	13.5 (H)

*Twin-type **Total for both units ▲ For parallel-heater connection ● For series-heater connection ■ Maximum ratings for amateur use †May be higher, depending on cooling techniques § In "two-tone" operation. For a signal having a minimum peak-to-average power ratio less than 2, such as in "single-tone" operation, this value is 660 watts.

For technical data on any of these types, write RCA, Commercial Engineering, Harrison, N.J.



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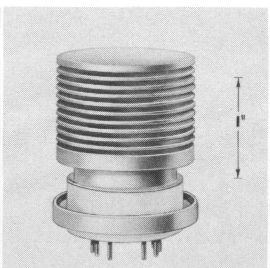
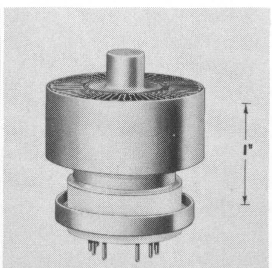


RCA-8121



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Harvey Slovik, Editor

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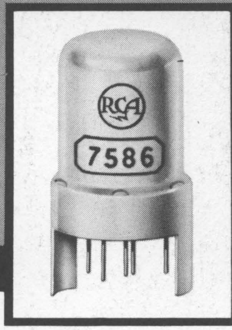


SPRING, 1962

NUVISTOR TWO-METER TRANSMITTER

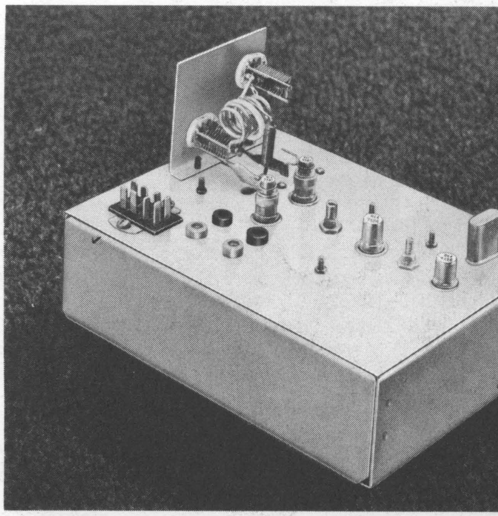
By R. M. Mendelson, W2OKO

RCA Electron Tube Division, Harrison, N. J.

Announcement of a new tube usually starts the construction-minded ham searching for ways to take full advantage of its improvements over older tube types. And when a whole series of new types, such as RCA's nuvistor line, is introduced, the experimental possibilities become almost limitless.

To date, HAM TIPS articles on nuvistor applications have been concerned solely with receiving circuits. (Consider the nuvistor two-meter converter and the nuvistor preamplifier, described respectively in the May, 1961, and September, 1961, issues.) Can the amateur make good use of these same receiving tubes in low-power transmitters? Yes! RCA nuvistors are ideal for miniaturized VHF mobile or fixed-station transmitting operation. These tubes have high plate-dissipation ratings for their small size; they are easily usable up to 400 megacycles; and they have the rugged construction required for mobile operation.

The transmitter featured in this issue points up the versatility of RCA nuvistors—and how easily they may be put to work as transmitting tubes. An RCA-7586 nuvistor triode is used in a conventional overtone crystal oscillator at 48 Mc. Unnecessary loading of the oscillator is prevented by operating the tube with no frequency multiplication. The second-stage 7586 triples the frequency to 144 Mc and provides the drive to the final stage. A pair of RCA-7587 nuvistor tetrodes used in the final amplifier can be operated with a power input of up to 7½ watts. The very low driving power for these tubes is easily supplied by the tripler stage. Screen-grid neutralization is used, but adjustment is not critical.

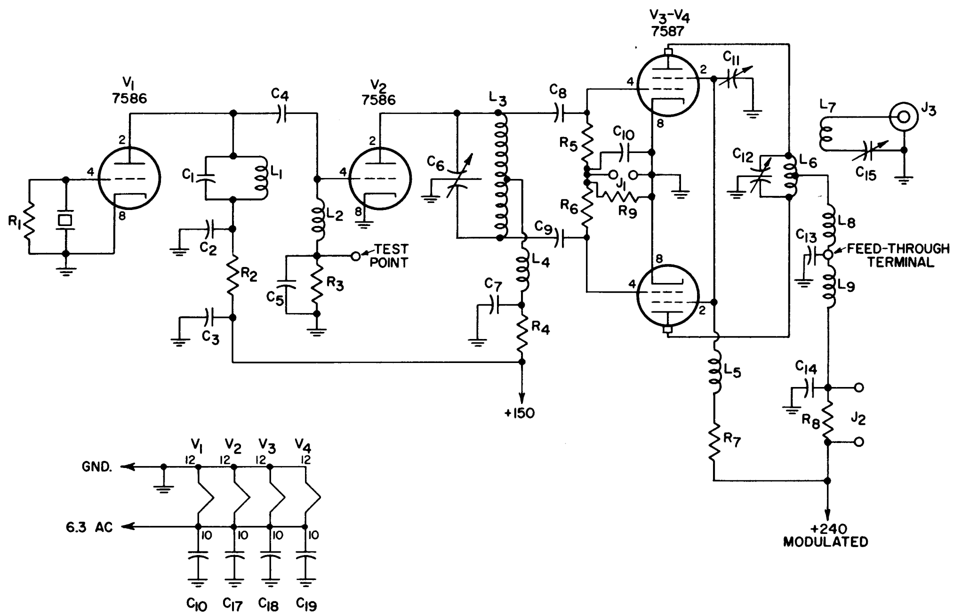


Top view of W2OKO's two-meter transmitter designed around two RCA-7586 nuvistor triodes and a pair of RCA-7587 nuvistor tetrodes.

Figure 1 presents the complete schematic diagram and parts list for the nuvistor two-meter transmitter. Table I shows typical operating voltages and currents.

Construction

The entire transmitter is built on a 5- by 7-inch piece of copper or brass, so that a standard aluminum chassis may be used as the base cover. A smaller plate can be used without cramping the parts if a special cover is hand bent. (Refer to Figure 2 for the parts



C_1—30 pf ceramic tubular (Centralab TCZ-30 or equiv.)
C_2, C_3—.01 μf ceramic disc (Centralab DD-1032 or equiv.)
C_4—50 pf ceramic tubular (Centralab TCZ-50 or equiv.)
C_5, C_7, C_{10}, C_{13}, C_{14}, C_{16}, C_{17}, C_{18}, C_{19}—500 pf ceramic tubular (Centralab DD-501 or equiv.)
C_6, C_{12}—2.7-10.8 pf butterfly air capacitor (Johnson 11MB11 or equiv.)
C_8, C_9—20 pf ceramic tubular (Erie TCO-20 or equiv.)
C_{11}—7-45 pf ceramic trimmer (Erie TS-E or equiv.)
C_{15}—3-32 pf air trimmer capacitor (Johnson 30M8 or equiv.)
J_1, J_2—Pair each, insulated phone tip jacks
J_3—Coax jack type BNC
L_1—4¼ turns #26 enameled wire, ⅜-inch diameter, spaced wire diameter on slug tuned form (CTC LS3 or equiv.)
L_2—RFC 7 μh (Ohmite Z50 or equiv.)
L_3—4 turns #16 bare wire, ½-inch diameter, ⅝-inch long, tapped at center
L_4, L_5, L_8, L_9—RFC 1.7 μh (Ohmite Z144 or equiv.)
L_6—5 turns #14 bare wire, ½-inch diameter, ⅝-inch long, tapped at center
L_7—1 turn #14 bare wire, ¾-inch diameter, insulated with "spaghetti"
R_1—100,000 ohm, ½ watt
R_2, R_4—5,600 ohm, ½ watt
R_3—15,000 ohm, ½ watt
R_5, R_6—6,800 ohm, ½ watt
R_7—27,000 ohm, ½ watt
R_8—100 ohm, ½ watt
R_9—1,000 ohm, ½ watt
Crystal socket
Feed-through terminal
Crystal—48.0-49.33 overtone (International Crystal Co. type FA5 or equiv.)
4 nuvistor sockets (Cinch No. 133 65 100.011)
1 socket (Jones type P308 AB or equiv.)
1 chassis, aluminum, 5″ x 7″ x 2″ (Bud AC402 or equiv.)

Figure 1: Schematic diagram and parts list.

layout that assures short leads and correct parts orientation. Also see Figure 3 for a sketch of the small bracket to be used in mounting the final tank circuit and output coaxial connector.)

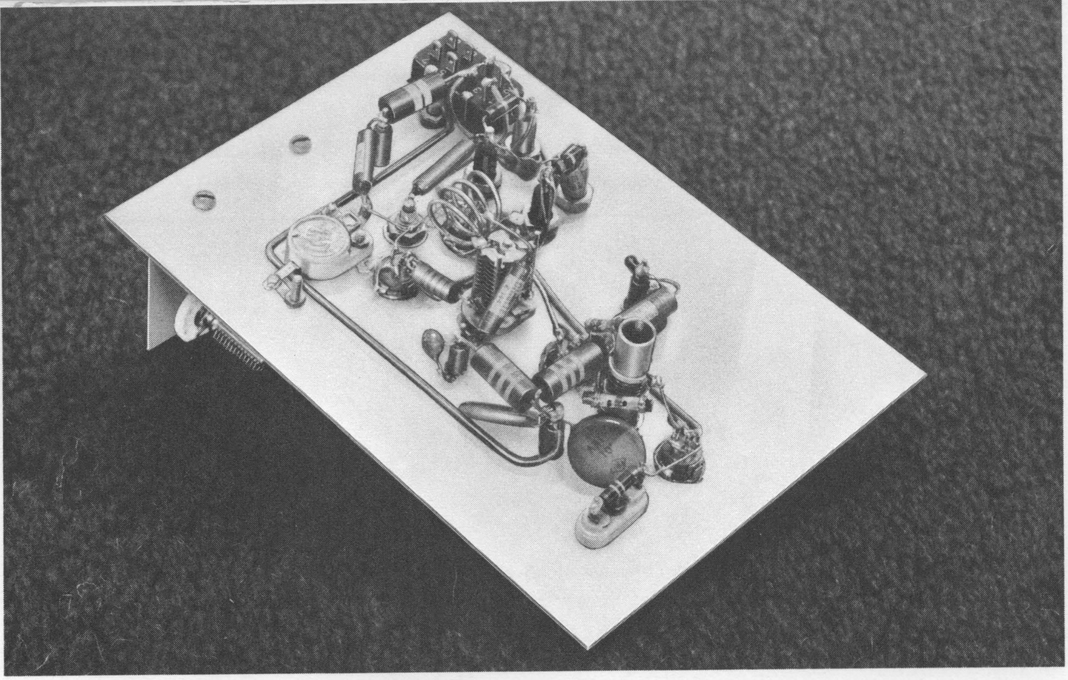
Because of their small size, nuvistor sockets are clamped, not bolted, to the chassis by bending two lugs on the socket. After the chassis hole has been drilled, two notches for the lugs are hand filed to insure a tight fit of socket to chassis. For rf grounding, both socket lugs are soldered to the chassis plate.

Adequate rf bypassing is applied to all critical parts of the circuit. Because the reliability of nuvistors makes it unnecessary to retune the transmitter every time it is put into service, a permanent meter is not required. Rather, two pairs of jacks are used for plugging a temporary meter into the grid or plate circuits of the final. An eight-contact power socket provides extra contacts for future development.

The plate caps for the tetrode are made by bending a piece of piano wire into a tight-fitting one-turn coil. To keep lead inductance low, the leads to the plate tank capacitor are made from ¼-inch-wide copper ribbon. The one-turn output link is covered with a piece of "spaghetti" insulation and tightly coupled to the final tank coil.

Adjustment

The transmitter is very easy to tune. If all the coils have been wound to specification, there should be no trouble in finding the proper settings of the coil slug and of the



Bottom view of author's nuvistor two-meter transmitter.

tuning capacitors. Of course, a grid-dip meter makes tuning even easier.

To assure that the oscillator will start every time voltage is applied, follow this procedure: Plug in only the first RCA-7586 and the crystal; apply heater voltage and +150-volt plate voltage, and allow the tube to warm up. With a high-impedance voltmeter applied to the test terminal, adjust the slug in coil L_1 until oscillation starts (shown by voltage at the test point). Adjust for maximum voltage; then back the slug out to give a slightly higher tuned frequency. A reading of about 10 volts should be obtained.

Next, plug in the second RCA-7586 and the two RCA-7587's. Do not apply plate and screen-grid voltage to the final as yet. Plug a 5-milliampere meter into the grid jack pair, J_1, and tune C_6 for maximum grid current. A reading of between 2 and 3 milliamperes should be obtained.

Then, rotate the plate-tuning capacitor, C_{12}, through its entire range. There should be very little effect on the grid-current reading. In turn, slowly adjust the screen-grid bypass capacitor, C_{11}, while rotating the plate capacitor until a point is found at which the plate capacitor has no effect on the grid current. This adjustment is not critical.

Now that the final stage is neutralized, plug a 50-milliampere meter into the final plate-circuit pair, J_2; attach the antenna or dummy load, and apply +240 volts to the plate and screen-grid circuit. Tune the plate

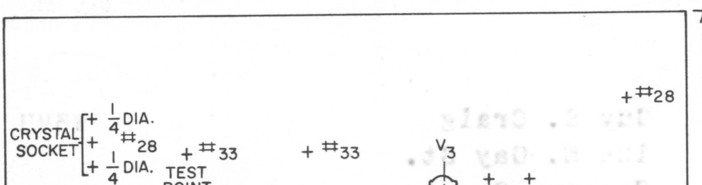


Figure 2 (at left): Bottom view of chassis plate (one-half actual size).

Figure 3 (below): Diagram for the final-stage mounting bracket.

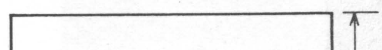


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TABLE I: TYPICAL OPERATING VOLTAGES AND CURRENTS

(All voltages are measured with respect to ground and may vary by 20%)

Voltage to ground	V_1	V_2	V_3, V_4
Plate	100	86	240 Volts
Screen Grid	—	—	75 Volts
Control Grid*	-9.5	-9.2	-15.1 Volts
Cathode	0	0	0 Volts
Currents			
Control Grid Final	—	—	2.3 Milliamperes
Screen Final	—	—	5.0 Milliamperes
Plate Final	—	—	32.0 Milliamperes

*Measured with vacuum-tube voltmeter. A low impedance meter will affect the circuit values.

tank for minimum plate current with capacitor C_{12}. The tuning capacitor, C_{15}, in the output link is for balancing out feed-line reactance to the antenna and should be adjusted for best output. (Use a standing-wave-ratio bridge, a field-strength meter, or even signal-reports from another station.) When fully loaded, a plate current of about 32 milliamperes should be obtained.

Conclusion

Only after using this transmitter will the operator realize the merits of nuvistor ruggedness and reliability. Long periods of operation, or even long periods of idleness, have no effect on the nuvistor transmitter. It will stay tuned and ready to work well whenever needed.

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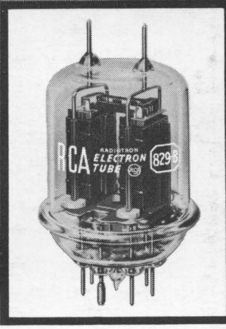


A 120-WATT 50-MC TRANSMITTER

By George D. Hanchett, W2YM

RCA Semiconductor and Materials Division

Somerville, N. J.

Although an active ham for more than three decades, the author had never tried transmission on six meters—until this year. Preparatory steps involved the usual search around the shack for parts suitable for a low-powered rig. W2YM decided that only the rf unit and antenna had to be built. Power supplies and the modulator were borrowed from a two-meter transmitter. The available power supplies limited the rig to a power level of about 100 watts. Because the author's location is in a Channel-2 area, the 120-watt 50-megacycle transmitter—well shielded throughout—is of proved straightforward design.

Front view of W2YM's 120-watt 50-megacycle transmitter. [Note the air-intake holes on the side of the blower (or bottom) chassis. They each measure 3/8 inch in diameter.]

Tube Locations and Circuit Considerations

Initial step in planning the 120-watt 50-megacycle transmitter was to lay out a three-stage rf section having a VFO-driven multiplier or crystal oscillator as the first stage and an RCA-829B as the final stage (see Figure 1).

An RCA-12BY7A oscillator-tripler was arranged so that it operates as a grid-plate oscillator in the crystal-control position. This oscillator uses 8-megacycle crystals and its output is tuned to the third harmonic. In the VFO position, the 12BY7A stage can be either an amplifier or a multiplier, and can be driven by a VFO with 8-, 12-, or 25-Mc output.

The oscillator-multiplier is capacitively coupled to an RCA-2E26 doubler which has a 50-Mc output. The 2E26 is link-coupled to the grids of the 829B. Link coupling was used because it facilitates coupling of a single-ended stage to push-pull grids.

In addition, the use of the double-tuned circuit provides extra selectivity in the grid circuit of the 829B amplifier and, thereby, reduces the possibility of harmonic interference to FM and TV reception.

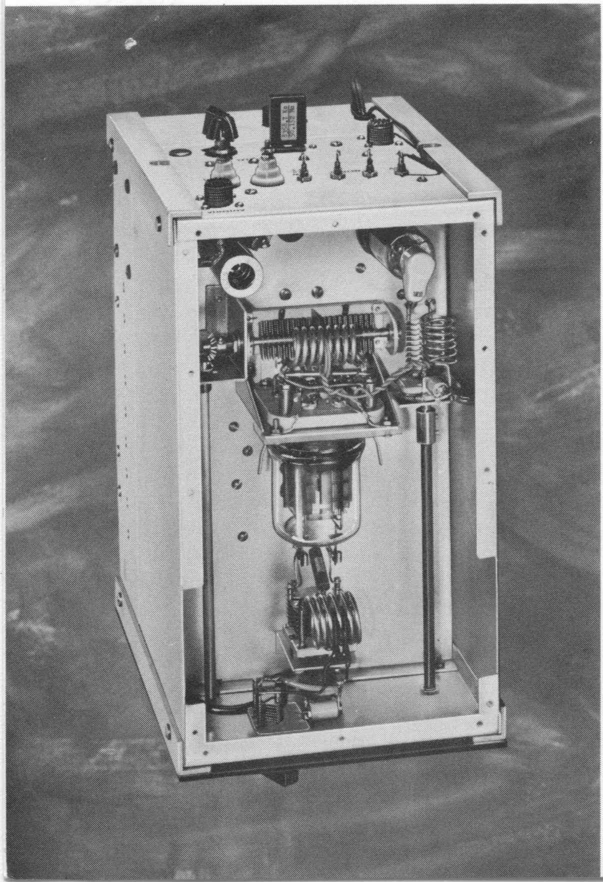
The 829B final-amplifier plate circuit is tuned by a butterfly capacitor. The rotor section of this capacitor is ungrounded to improve balance. The antenna is link-coupled to the final tank circuit and is equipped with a 50-micromicrofarad capacitor which tunes out the inductance of the link winding.

Metering of different circuits is accomplished by use of a 0-1 milliampere meter. Suitable meter shunts are used in order to meter oscillator plate current (30 milliamperes full scale), doubler-grid current (2 ma full scale), doubler plate current (100 ma full scale), final grid current (30 ma full scale), final screen-grid current (100 ma full scale), and final plate current (300 ma full scale). A tuning switch is incorporated because it not only aids in the tune-up procedure, but also saves tubes and prevents possible damage to other components.

Construction

Completely contained in a 12- by 7- by 6-inch aluminum utility box, the 50-megacycle transmitter is fitted with an aluminum subchassis. This subchassis has small, ½-inch lips which are bent on the long sides of the chassis to provide stiffness.

Top view of inside of utility box shows details of grid and plate circuit for the 829B. Also note that a portion of the utility-box flanges have been removed to allow for insertion of subchassis.



Half-inch tabs—bent on the front and rear of the chassis—serve as mounting brackets. One set of these tabs is bent up, the other down. Without this feature it would be impossible to insert the subchassis into the utility box.

For the same reason, two slots are cut in the top flanges of the utility box. These slots are visible in the photograph at left, which shows a top view of the transmitter.

A rectangular cutout at the rear of the subchassis fits around the power-lead filters which are mounted on the rear wall of the utility box. All leads entering or leaving the utility box are brought out through low-pass filters.

When complete, the utility box is mounted on a 12- by 7- by 3-inch aluminum chassis that serves as a bottom cover as well as a housing for the cooling fan and filament transformer. (The schematic for the bottom chassis is shown in Figure 2.)

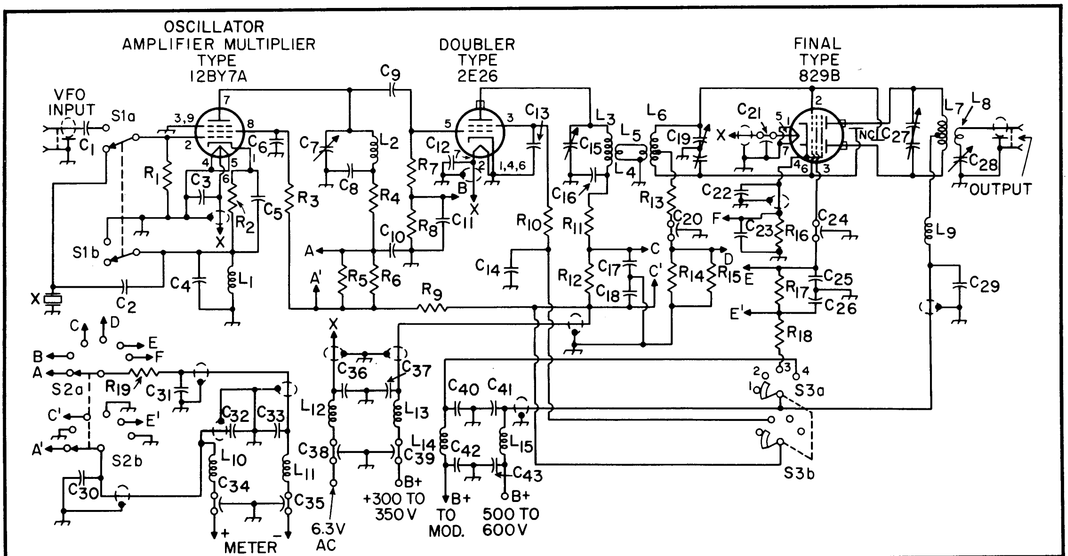
A right-angle drive for the final-amplifier grid capacitor was made from two brass-beveled gears manufactured by the Boston Gear Works. These gears (stock item No. G462Y) have a 3/16-inch shaft hole which must be enlarged to accommodate ¼-inch shafts. (The use of a lathe is recommended for this machining. If you do not have access to a lathe, a machine shop will do it for you at a nominal fee.) Each gear is secured on its shaft with two Allen-set screws spaced 90 degrees apart.

As shown in the sketch of the grid assembly (see Figure 3), the socket, grid coil, and neutralizing capacitors for the 829B are mounted on an aluminum bracket. The two top-mounting screws of the socket, together with a polyethylene strip, are used as feed-through connections.

The holes in the brackets must be enlarged so that the neutralizing capacitors do not short to ground. In the Figure 3 sketch, these holes are enlarged to ⅜ inch.

Note that, during construction, the grid leads of the 829B are criss-crossed. The neutralizing capacitors are small pieces of No. 12 wire which are close to the plate region of the 829B. Neutralization is accomplished by adjustment of the length of these wires, as described below.

The heater, screen-grid, and control-grid by-pass capacitors (as well as the output capacitor of the low-pass filters for the meter



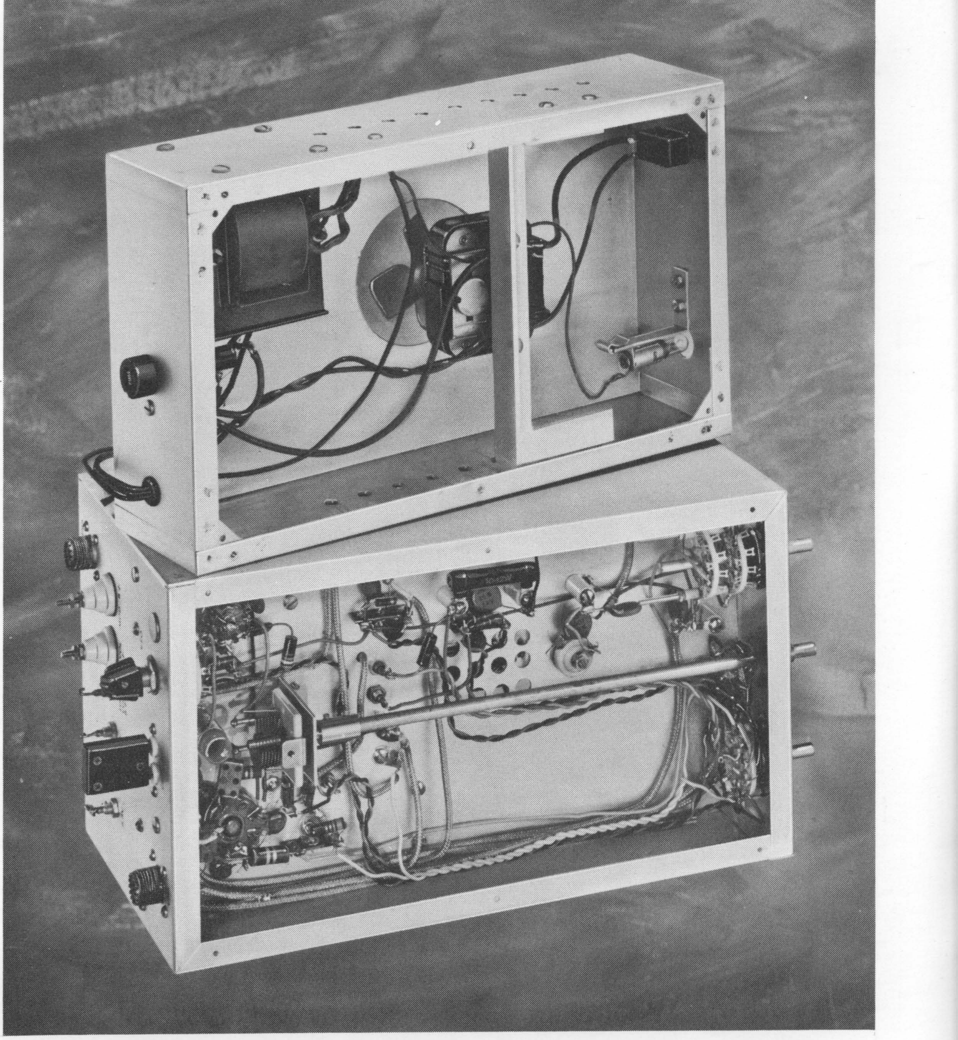
C_1—220 pf, mica, 500 volts
C_2—10 pf, mica, 500 volts
C_3, C_5, C_6, C_8, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{16}, C_{17}, C_{18}, C_{22}, C_{23}, C_{25}, C_{26}, C_{30}, C_{31}, C_{32}, C_{33}, C_{36}, C_{37}—1,000 pf, disc ceramic, 1,000 volts
C_4—100 pf, mica, 500 volts
C_7, C_{28}—3.7-52 pf, variable, air gap 0.015 inch (Hammarlund HF-50 or equiv.)
C_9—47 pf, mica, 500 volts
C_{15}—5.2-30 pf, variable, air gap 0.045 inch (Hammarlund HF 30-X or equiv.)
C_{19}—5.0-28.5 pf double-section variable, air gap 0.045 inch (Hammarlund HFD 30-X or equiv.)
C_{20}, C_{21}, C_{24}, C_{34}, C_{35}, C_{38}, C_{39}—1,000 pf, feed-through, ceramic, 500 volts
C_{27}—4.8-27.3 pf, butterfly, variable, air gap 0.030 inch (Hammarlund BFC-25 or equiv.)
C_{29}, C_{40}, C_{41}, C_{42}, C_{43}—1,000 pf, disc ceramic, 3,000 volts
L_1—RF choke, 1 mh
L_2—10 turns of No. 20 tinned on ½-inch diameter form, winding length ¾ inch
L_3—5½ turns of No. 10 solid on ⅝-inch diameter, winding length 1 inch
L_4, L_5—2 turns of No. 20 plastic covered on ½-inch diameter
L_6—8 turns of No. 10 solid on ⅝-inch diameter, winding length 1½ inches
L_7—6 turns of No. 10 solid on ⅞-inch diameter, winding length 1 inch
L_8—2 turns on No. 14 Enam. covered with insulation tubing on ⅝-inch diameter
L_9, L_{10}, L_{11}, L_{13}, L_{14}, L_{15}—RF choke, 7 μh, 1,000 ma (Ohmite Z-50 or equiv.)
L_{12}—RF choke, 25 turns of No. 16 Enam. close-wound on ¼-inch diameter
NC—Neutralizing capacitors: No. 12, tinned wire (½-inch length placed in proximity of 829B plates); see text
R_1—100,000 ohms, 0.5 watt
R_2—120 ohms, 0.5 watt
R_3—33,000 ohms, 0.5 watt
R_4, R_8, R_{11}, R_{19}—1,000 ohms, 0.5 watt
R_5, R_{14}—47 ohms, 0.5 watt
R_6, R_{15}—130 ohms, 0.5 watt
R_7—47,000 ohms, 1 watt
R_9—3,300 ohms, 1 watt
R_{10}—10,000 ohms, 2 watts
R_{12}—10 ohms, 0.5 watt
R_{13}—56,000 ohms, 2 watts
R_{16}—3.3 ohms, 0.5 watt
R_{17}—33 ohms, 0.5 watt
R_{18}—15,000 ohms, 10 watts, wire wound
S_1—Crystal-VFO Switch; two-pole, two-position, wafer, non-shorting, rotary
S_2—Meter Switch; two-pole, six-position, wafer, non-shorting, rotary
S_3—Tuning Switch; 60-degree indexing (Centralab PA-304 or equiv.); two progressively shorting 30-degree wafers (Centralab PA-12 or equiv.), using every second contact
Miscellaneous—One crystal socket; one 829B socket; one octal socket; one 9-pin min. socket and shield; one 6- x 7- x 12-inch utility box; one 7- x 12- x 3-inch chassis; two ceramic feed-through insulators; two beveled gears, 90 degrees; one pilot light (green); one fuse; one cord set; one insulated plate cap (Millen or equiv.); two coaxial connectors (Amphenol or equiv.) **Note: All resistors have 10% tolerance.**

Figure 1: Schematic diagram and parts list of the rf section of W2YM's 50-megacycle transmitter.

leads, heaters, and 350-volt B+) are 0.001 μf FT feed-throughs. The high-voltage and modulator power-lead feed-throughs are ceramic units which are externally by-passed.

The tuning switch is constructed from a Centralab 60-degree detent assembly and two PA-12 progressively shorting wafers. In the first position, the screen-grid voltage is removed from both the 2E26 and the 829B, as well as the plate voltage to the external modulator. Advancing the switch in a clockwise manner activates each stage in turn until, in the fourth position, the complete transmitter is in operating condition.

As previously mentioned, the filament transformer and cooling fan are mounted in



Bottom views of both utility box and blower chassis before assembly as combined unit. Note blower fan in the blower chassis. Also note that the 12 holes in the subchassis underneath the 829B allow for free flow of air around the tube.

the blower (or bottom) chassis (Figure 2). The cooling-fan blade is positioned in a 2¾-inch hole in the blower chassis. Holes drilled in the sides of this chassis provide an air inlet for the fan. As a result, air is freely circulated around the 829B.

Although the bottom cover is one of the original utility box covers, the top cover is a piece of perforated aluminum. The utility box and the blower chassis are held together by four ¾-inch angles which can be made from "do-it-yourself aluminum." The front panel is cut from ⅛-inch aluminum stock and fastened to the front aluminum angles of the transmitter. The panel may then be painted and lettered with decals.

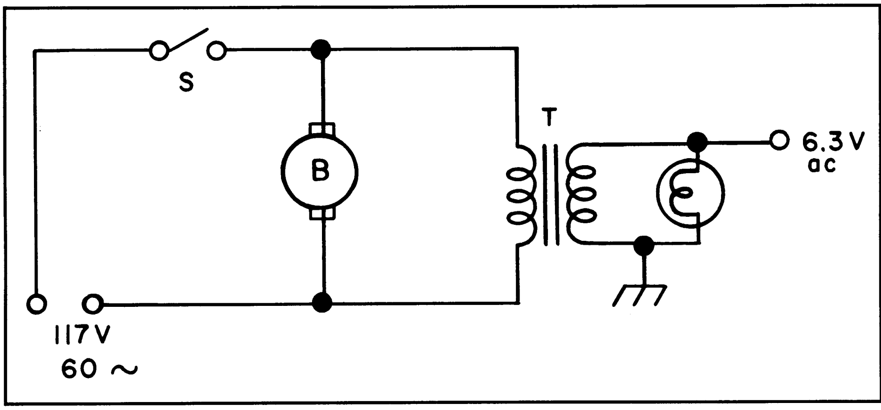
In the transmitter, the 0-1 milliampere meter is not included because it is an integral part of the power supply unit used. Figures 4 and 5 show the power supplies that have been successfully used with this transmitter.

Transmitter Adjustments

With the top and bottom covers removed and the utility box detached from the blower chassis, make temporary connections to the heater circuit and ground the utility box to the blower chassis. Then, after checking all wiring, turn on the ac power to the fan and heater-filament transformer.

See that all tubes are properly lit. With the tuning switch in position No. 1, temporarily connect the 300-volt B+ to its proper terminal. Turn on the power and adjust C_7 for the maximum grid current of the 2E26 (approximately 1.0 to 1.2 milliampere). Turn the meter switch so that the oscillator plate current can be read. (This value should be between 12 and 18 milliamperes.) With a wave meter or grid-dip meter in the diode position, check that the plate circuit of the 12BY7A is three times the crystal frequency.

Shut off the plate supply and advance the tuning switch to position No. 2. Reapply the 300-volt B+ and quickly adjust C_{15} and C_{19} for maximum 829B grid current. Adjust the link coupling so that a grid current of approximately 10 milliamperes is flowing to the 829B grid. In making adjustments of the link coupling, be sure you turn off the B+



B—117-volt tube-cooling fan and motor (Allied Radio #72P715)
S—Toggle switch (SPST)
T—6.3-volt filament transformer (6 amperes)

Figure 2: Schematic diagram and parts list of 50-megacycle transmitter's bottom chassis.

voltage because 300 volts is exposed at the 2E26 plate coil. At this point, by using a wave meter or grid-dip meter, check again that these circuits are on 50 megacycles.

If a dip in the grid-current occurs with excitation while C_{27} is tuned, the 829B neutralization must be adjusted by cutting ⅛-inch lengths from the neutralizing wires until there is no noticeable change in the grid current as C_{27} is tuned through resonance.

Next, connect a load to the antenna connector of the transmitter. (If you do not have a non-inductive 50- or 75-ohm load, a 100-watt light bulb can be substituted.)

Temporarily attach the 600-volt high-voltage lead to its proper terminal. With the tun-

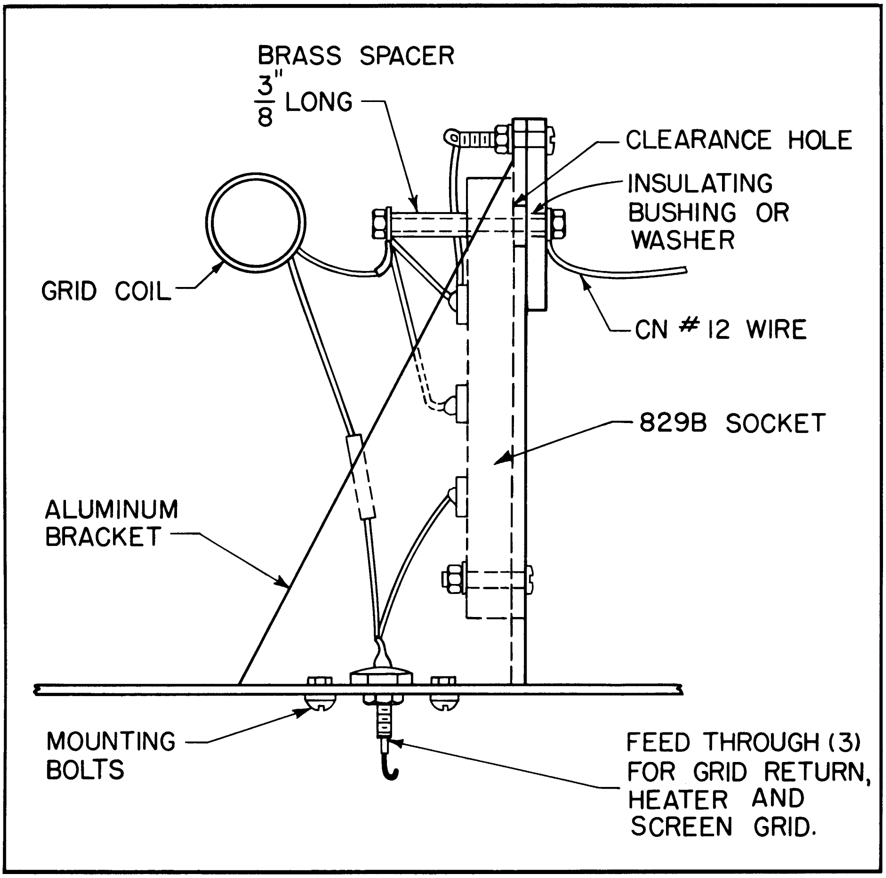


Figure 3: Sketch of grid assembly shows details of grid coil mounting and neutralizing capacitors.

ing switch in position No. 3 and the meter switch in the 829B cathode-current position, turn on the plate supplies. Quickly rotate the plate tank capacitor C_{27} for minimum dip. Now load the amplifier by adjusting L_8 and C_{28} until the total cathode current is approximately 200 milliamperes.

Return the meter to the 829B grid position and adjust the link coupling between the 2E26 and the 829B until the grid current is 15 milliamperes. Again return the meter switch to the cathode-current position and adjust the loading until the cathode current is approximately 240 milliamperes.

The 829B screen-grid current should now be between 25 and 30 milliamperes. If the screen-grid current is above 30 milliamperes, the screen-grid dropping resistor must be increased; if below 25 milliamperes, it must be decreased. It is unlikely, however, that you will require any adjustment of this dropping resistor.

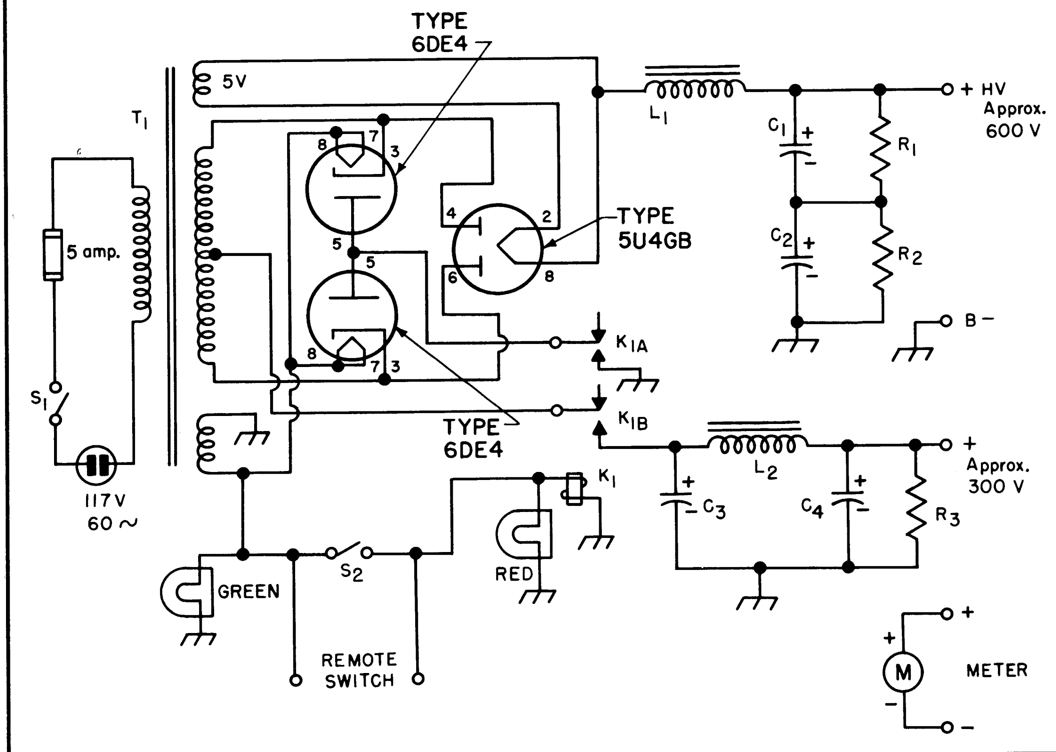
The utility box now can be assembled to the blower chassis. The bottom cover, as well as the top perforated cover, also can be permanently attached. The transmitter and modulator leads can be connected permanently, too. What else? Connect a six-meter antenna and you are ready to go on the air.

A few words of precaution: Never attempt to modulate this transmitter unless the 829B is completely loaded. If the transmitter is not loaded, flash-over will occur, since the butterfly capacitor voltage breakdown ratings will be exceeded. An output in the order of 75 to 85 watts should be attained.

Tube Selection

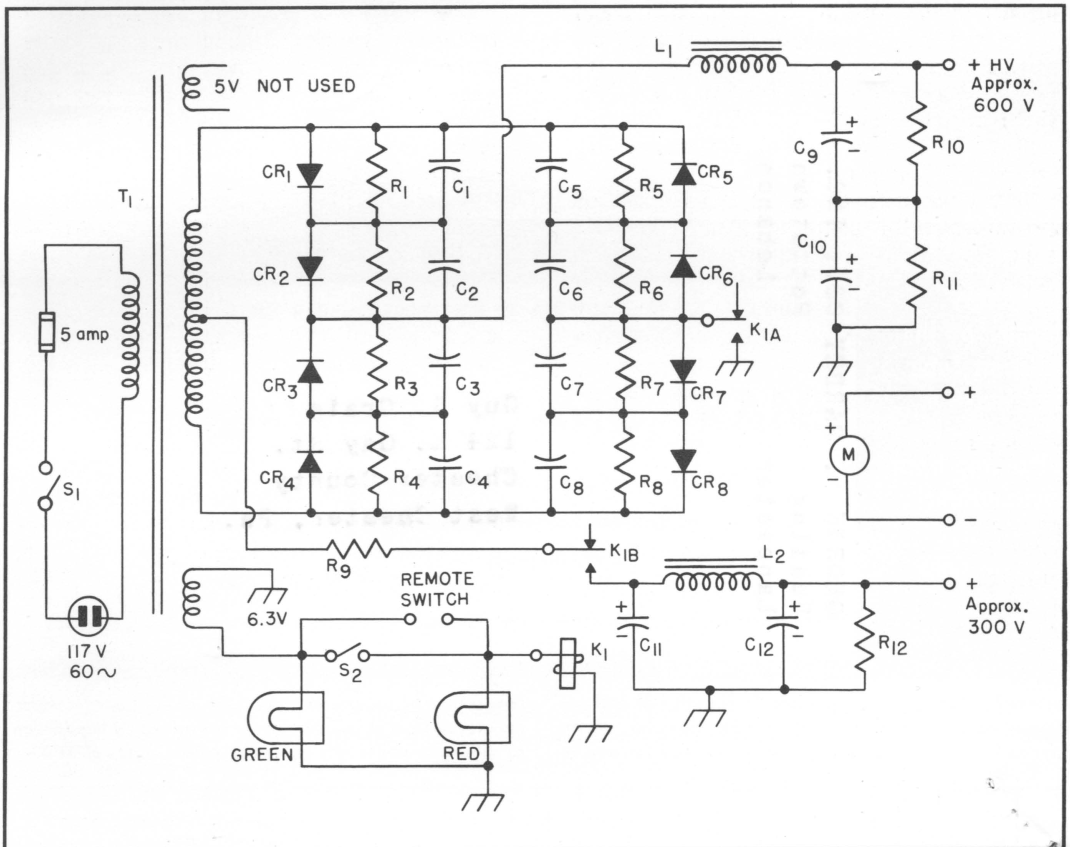
Potential builders of this 120-watt 50-megacycle transmitter may be interested in knowing why particular tube types were selected. Here are the more important reasons:

• This writer was interested in attaining high reliability consistent with a moderate



C_1, C_2, C_3, C_4—40 μf, 450 volts, electrolytic
K_1—Relay (Potter and Brumfield KA11AY or equiv.)
L_1—2.8 henry, 300 ma (Stancor C-2334 or equiv.)
L_2—4 henry, 175 ma (Stancor C-1410 or equiv.)
M—Milliammeter 0-1 ma dc
R_1, R_2—15,000 ohms, 10 watts
R_3—47,000 ohms, 2 watts
S_1—Toggle switch (SPST)
T_1—Power transformer (Stancor P-8159 or equiv.)

Figure 4: Schematic diagram and parts list of suggested power supply circuit using vacuum rectifier tubes.



C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8—.001 μf, 1,000 volts, disc ceramic
C_9, C_{10}—40 μf, 450 volts
CR_1, CR_2, CR_3, CR_4, CR_5, CR_6, CR_7, CR_8—RCA-1N2864
K_1—Relay (Potter and Brumfield KA11AY or equiv.)
L_1—2.8 henry, 300 ma (Stancor C-2334 or equiv.)
L_2—4.0 henry, 175 ma (Stancor C-1410 or equiv.)
M—Milliammeter 0-1 ma meter, dc
R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8—100,000 ohms, 0.5 watt
R_9—47 ohms, 1 watt
R_{10}, R_{11}—15,000 ohms, 10 watts
R_{12}—47,000 ohms, 2 watts
S_1, S_2—Toggle switches (SPST)
T—Power transformers (Stancor P-8166 or equiv.)

Figure 5: Schematic diagram and parts list of suggested power supply circuit using silicon rectifiers.

cost. The tubes chosen have been in production for many years and have demonstrated excellent life characteristics.

• Instead of the 829B, two 6146's could have been used for the final stage. However, the spacing and construction would have been much more difficult. In addition, while the 6146 would have cost less, the difference in price between this tube and the one used was not great enough to justify the extra mechanical problems that would have been brought about as a result.

• By replacement of the 2E26 with its 12-volt version (the 6893), and by rewiring of the 12BY7A and 829B, the transmitter can be used—with 12-volt heaters—in mobile installations.

All in all, the tube line-up selected appears to provide the best balance of power, cost, and reliability.

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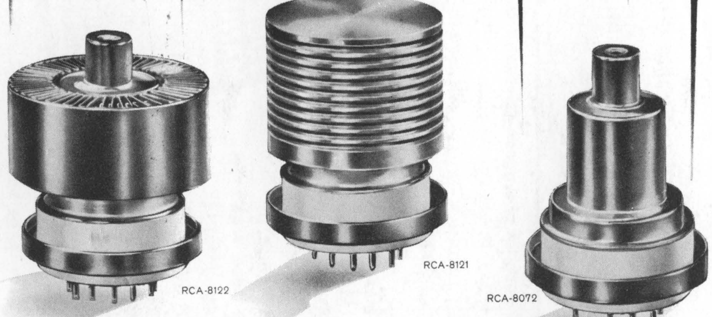

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A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

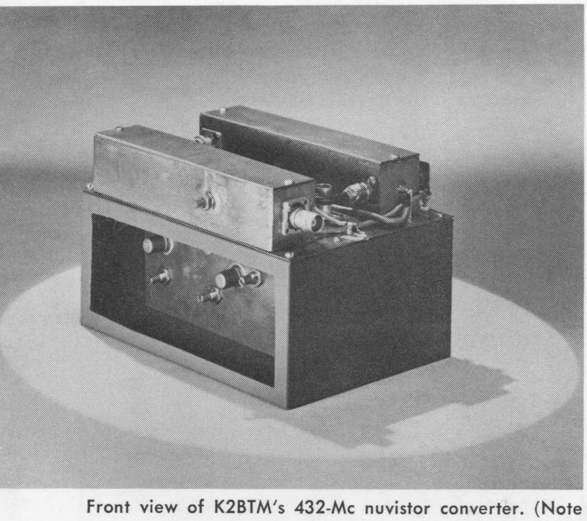
VOL. 22, NO. 3 FALL, 1962

A NUVISTOR CONVERTER FOR 432 MEGACYCLES

By J. M. Filipczak, K2BTM

RCA Electron Tube Division, Harrison, N. J.

New performance possibilities in the field of amateur receiver equipment resulting from the introduction of RCA nuvistors have led increasing numbers of hams to explore the various frequencies which might fully utilize the wide capabilities of these unique tubes. After achieving notable successes in one area, the author—like many of his fellow hams—was encouraged to proceed with experimentation in another. Excellent results with nuvistor converters for 144 and 220 megacycles in the VHF band soon prompted him to investigate designs for the UHF band. In the following article, he reports on a nuvistor converter for 432 megacycles—a highly dependable unit which "... has produced many hours of enjoyable QSO's."



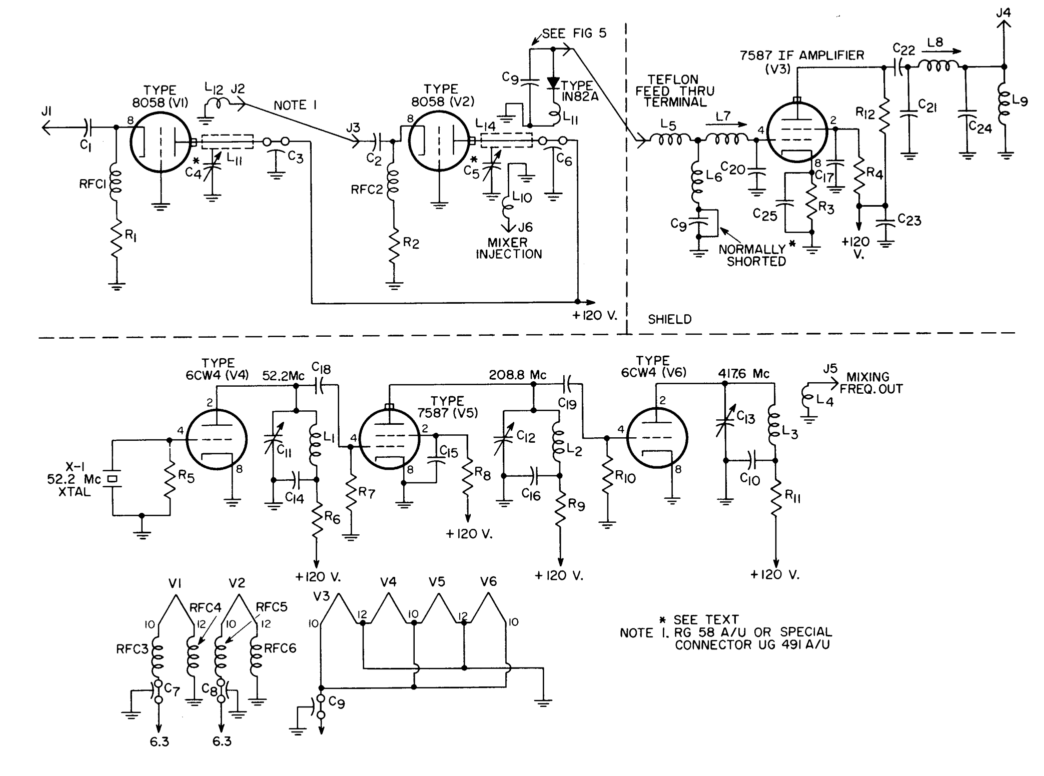
Front view of K2BTM's 432-Mc nuvistor converter. (Note how portion of chassis has been removed to facilitate final adjustments and additional cooling of oscillator-multiplier section.)

Description

This article describes a nuvistor converter for the 432-megacycle UHF band. As shown in the schematic diagram (Figure 1), the converter has two rf amplifier stages. Both stages employ the RCA-8058, a double-ended high-mu nuvistor triode which was announced commercially early in 1962.

This nuvistor type has been used successfully in cathode-drive amplifier service at frequencies up to 1200 Mc. Although its cost is somewhat higher than other nuvistor types, it is inexpensive when compared with other industry vacuum tubes capable of operating up to 1200 Mc.

Demonstrating excellent stability over a wide range of frequencies, the 8058 is designed to provide high gain with low noise in cathode-drive amplifier service. It is particularly suited to such service because the peripheral lugs used for indexing are also used as the connections to the grid. Further-



C_1, C_2—100 pf, ceramic tubular (Centralab TC2 or equiv.)

C_3, C_6, C_7, C_8, C_9—1,000 pf, feed-thru (Erie 2404)

C_4, C_5—See Figure 3

C_{10}—500 pf, silver button (Erie 370CB-501K or equiv.)

C_{11}—20 pf, miniature (E. F. Johnson 20M11)

C_{12}—15 pf, miniature (E. F. Johnson 15M11)

C_{13}—5 pf, miniature (E. F. Johnson 5M11)

C_{14}, C_{15}, C_{16}, C_{17}—500 pf, disc ceramic (Centralab DD501 or equiv.)

C_{18}, C_{19}—5 pf, ceramic tubular Centralab TCN or equiv.)

C_{20}—5 pf, N.P.O. ceramic (Centralab DT2 or equiv.)

C_{21}—15 pf, N.P.O. ceramic (Centralab DT2 or equiv.)

C_{22}, C_{23}—1,000 pf, disc ceramic (Centralab DD102-G or equiv.)

C_{24}—100 pf, silver mica (Arco Electronics CM-15 or equiv.)

C_{25}—.003 disc ceramic (Centralab DD302 or equiv.)

J_1, J_2, J_3, J_4—BNC-type connector (UG290AU)

J_5, J_6—RCA-type phono connector

L_1—6 turns of No. 20 on ½-inch diameter (B&W 3003)

L_2—1 turn of No. 18 enamelled wire on ½-inch diameter

L_3—See Figure 3

L_4—Hairpin loop, No. 16 enamelled wire cut to ½-inch length

L_5, L_9—9 turns of No. 26 enamelled wire, close wound on ¼-inch diameter poly form

L_6—18 turns of No. 26 enamelled wire, close wound on ¼-inch diameter poly form

L_7—28 turns of No. 26 enamelled wire, close wound on ⅜-inch diameter slug-tuned form (CTC-PLST or equiv.)

L_8—20 turns of No. 26 enamelled wire, close wound on ⅜-inch diameter slug-tuned form (CTC-PLST or equiv.)

L_{10}—Hairpin loop, No. 18 enamelled wire cut to ½-inch length

L_{11}—No. 18 insulated wire, ¾-inch length, bent into loop and coupled approximately ⅛-inch from L_{14}

L_{12}—Same as L_{11}, except for coupling of loop to L_{13}

L_{13}, L_{14}—See Figure 3

R_1, R_2—56 ohm, ½ watt

R_3—68 ohm, ½ watt

R_4—47,000 ohm, ½ watt

R_5—47,000-to-100,000 ohm, ½ watt (See text)

R_6—4,700 ohm, ½ watt

R_7, R_{10}—100,000 ohm, ½ watt

R_8—120,000 ohm, ½ watt

R_9—1,000 ohm, ½ watt

R_{11}—22,000 ohm, ½ watt

RFC_1, RFC_2, RFC_3, RFC_4, RFC_5, RFC_6—Ohmite Z460 rf choke

Miscellaneous—One feed-thru Teflon insulator; crystal socket; one crystal 52.2-Mc overtone (International Crystal Company type FA5); six nuvistor sockets (Cinch No. 133 65 100.011); one chassis, aluminum, 5-by-7-by-3 inches (Bud AC429 or equiv.)

Figure 1: Schematic diagram and parts list of K2BTM's 432-Mc converter.

more, three base-pin connections for the cathode reduce lead inductance and provide flexibility in circuit layout.

The 8058 is especially useful in equipment which requires tubes having low drain and exceptionally high uniformity of characteristics. The double-ended construction of this nuvistor provides a high degree of isolation between the input and output circuits.

As indicated in the schematic, the second rf amplifier (V2) is identical to the first but is followed by a crystal mixer mounted on the chassis. Both stages use quarter-wavelength shorted plate lines. A noise figure of 7 db and a gain of 15 db at 450 megacycles have been measured for the first rf stage. In operation, signals which are generally hidden in the noise level of other converters are easily detected with this converter.

The output of the crystal mixer is link-coupled to a low-noise bandpass if amplifier which uses the RCA-7587, a general-purpose sharp-cutoff nuvistor tetrode. This nuvistor type is designed for use in a wide variety of small-signal applications requiring compactness, low current drain, relatively low-voltage operation, exceptional uniformity of characteristics from tube to tube, and ability to withstand severe mechanical shock and vibration.

Performance and stability of this tetrode stage have been most satisfactory. The gain of the if amplifier is about 20, and its output is fed to a receiver which tunes from 14 to 18 megacycles. A 52.2-megacycle overtone crystal in the oscillator-multiplier circuit multiplies the signal frequency up to the final injection frequency of 417.6 megacycles.

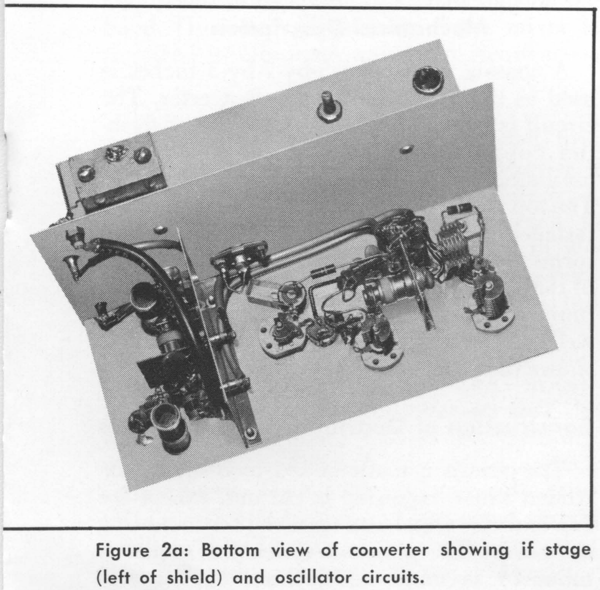


Figure 2a: Bottom view of converter showing if stage (left of shield) and oscillator circuits.

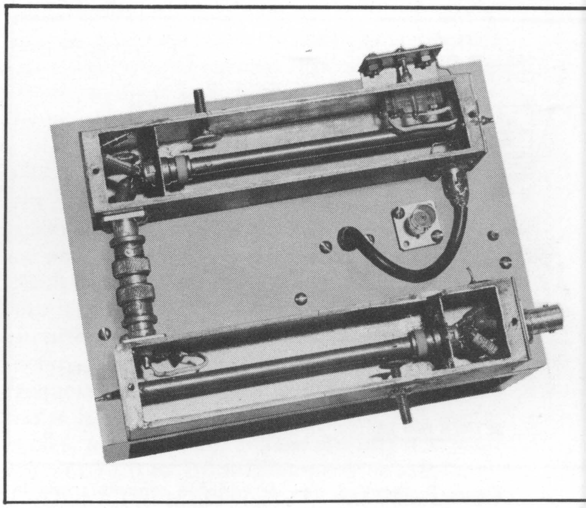


Figure 2b: Top view showing two rf amplifiers.

This frequency multiplication is accomplished with two RCA-6CW4 high-mu nuvistor triodes and a 7587 tetrode. The 6CW4 features high-gain capabilities which are achieved by very high transconductance and excellent transconductance-to-plate-current ratio (12500 micromhos at a plate current of 8 milliamperes and a plate voltage of 70 volts). The design of the oscillator-multiplier insures an adequate amount of injection frequency free of unwanted frequencies.

Power requirements for the converter are 120 volts at about 40 milliamperes and 6.3 volts ac at 950 milliamperes for the heaters.

Circuit Design

The first and second rf stages use the 8058 nuvistor in a grounded-grid (cathode-drive) configuration. The 8058 is especially suitable for this operation because the ground connection to the grid is made when the tube is inserted into the socket. Optimum performance of both rf stages occurs at about 430 megacycles; only a slight drop in gain occurs at 420 and 450 megacycles. Coupling from the antenna is through C_1 to the cathode of V1. The heaters are isolated above ground by rf chokes to provide stable operation. Oscillation has not been experienced in either stage.

As previously mentioned, the plate lines are quarter-wavelength shorted lines tuned by a small copper disc capacitor at the plate end. Plate voltage is fed to the line at the rf ground end through a 1000-picofarad capacitor. The

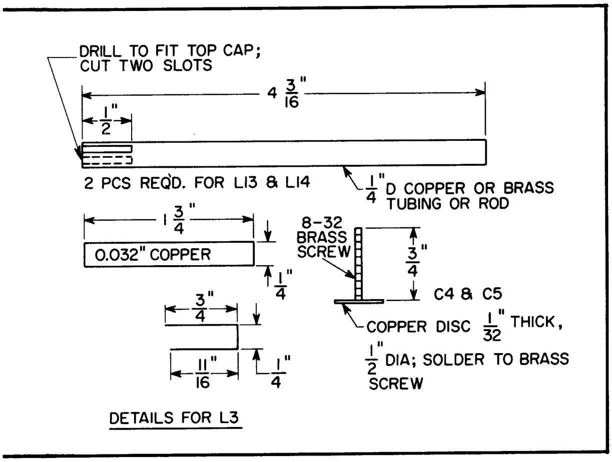


Figure 3: Detailed view of variable capacitors and inductors in rf stages.

two amplifiers are connected with a double BNC connector. Instead of this double connector, coaxial cable with conventional BNC fittings can be used.

The 1N82A crystal mixer is easy to construct, and was selected in preference to other types because it can take a considerable amount of rf voltage from the transmitter before burning out. Nevertheless, precautions should be taken for cutting off B+ during transmission to prevent damage to the rf circuits and the crystal mixer.

The output impedance of the crystal is matched to the input of the 7587 nuvistor (V3) by the coupling network (L_5, L_6, and L_7). Although this bandpass-coupling network is designed to operate at a frequency of 14 to 18 megacycles, slight retuning of coils (L_7, L_8) is required when tuning 16 to 18 megacycles. During normal operation, the capacitor C_7 is shorted to ground. During initial operating adjustments of the converter, the short across C_7 is removed, and a milliampere meter is placed in series with this point and ground. As a result, the crystal current can be measured and adjusted for normal operation. Noise measurements indicate that overall noise figure of the 7587 is less than other equivalent tubes.

Because the oscillator-multiplier circuit is of conventional design, no trouble should be encountered if good high-frequency wiring techniques are used. The 6CW4 (V4) oscillator stage is a harmonic overtone crystal circuit. Although slightly higher in cost than other crystals, overtone crystals are more accurate. Slight shifts in crystal frequency can be troublesome when multiplying to 417 megacycles. Because a number of receivers can tune below 14 megacycles and above 18 megacycles, a slight shift in the injection frequency can be compensated for.

When the 52.2-megacycle crystal in the grid circuit of the 6CW4 (V4) is oscillating, the plate circuit should be tuned to 52.2 megacycles. The high-value grid resistance (around 100,000 ohms) prevents excessive crystal current flow. Most active harmonic crystals oscillate readily with 100,000-ohm grid resistance. If this resistance is too high, however, it can be reduced to 47,000 ohms without causing excessive crystal current flow.

The next stage (V5)—a 7587 nuvistor tetrode—operates as a quadrupler and multiplies the frequency to 208.8 megacycles. The plate circuit is a single turn of #18 wire (½-inch diameter). The Q of this coil is sufficiently high to reject unwanted frequencies. This stage and the next doubler stage require extreme care in layout so that short direct connections can be made. Figures 2a and 2b show the positions of the components in these two stages.

The next nuvistor triode stage doubles the frequency to 417.6 megacycles. The plate-circuit inductance (L_3) is a short piece of copper bent into the shape of a "U." Construction details of this tank circuit and the other coil assemblies are shown in Figure 3.

The 417.6-megacycle injection frequency is link-coupled to the mixer stage through a short piece of 50-ohm coaxial cable. The coupling loop L_{10} is about 1/16 to 1/8 of an inch from L_{14}.

Mechanical Description

A chassis measuring 5-by-7-by-3 inches is used as the enclosure for the converter. The circuit is constructed on a flat piece of flashing copper with a shield separating the oscillator-multiplier from the if amplifier. The top plate is also 5-by-7-by-3 inches and is fastened to the aluminum chassis which forms the base for the two rf lines. One side of the aluminum chassis is cut out to facilitate tuning of the oscillator-multiplier circuits as well as the coils in the if amplifier. Figure 2 shows the position of the shields.

Construction of Quarter-Wavelength Lines

The chassis is made of 1¼-inch-square extruded brass. One side is cut out, except for two end ribs which are required for mounting the cover. The plate on which the socket is mounted is made of flashing copper and

soldered into position inside the brass extrusion. Position of components and dimensions for the lines are shown in Figures 2 and 4.

The crystal mixer is coupled to the line by means of coupling loop L_{11}, which is spaced 1/8 to 3/16 inch from the plate line. The ungrounded end of this loop is connected to a tube pin removed from an old octal tube. This pin is force-fitted into an insulating block mounted on the chassis. Details for this construction are shown in Figure 5. This arrangement does not require any soldering at either end of the crystal diode. The L-shaped bracket is made to a close tolerance, and permits electrical contacts to be made at either end of the crystal without soldering.

By the addition of another piece of copper and one layer of Teflon sheet 0.010-inch thick, the L-shaped bracket also becomes capacitor C_9, having a capacitance of 45 picofarads. The mixing frequency is injected to the plate line of the second rf amplifier by the coaxial cable, both ends of which use a "phono-type" jack.

The size of the mixer-coupling loop (L_{10}) determines the amount of crystal current. A piece of wire, approximately 1/2-inch in length, should be formed into a small loop. One end of this loop is connected to the phono socket and the other end is soldered to the chassis. Adjustment of the distance of the loop to the plate line determines the amount of injection voltage to the mixer and also the mixer crystal current flow. Precaution should be taken because excessive injection voltage may result in reception of signals outside the band. Optimum adjustment of the mixer is required to eliminate unwanted frequencies.

Adjustment Procedure

The oscillator-multiplier is adjusted first for normal operation. A grid-dip meter is a very useful instrument and is considered a necessity when building converters such as the one discussed here. Insert V4 (the 6CW4 oscillator) into its socket. Temporarily connect a milliammeter (10 milliamperes full scale) in series with the 4700-ohm resistor in the oscillator plate circuit. Apply 120 volts B+ and tune C_3 until a sharp "kick" in current on the milliammeter indicates that the circuit is oscillating. Couple the grid-dip meter near L_1 and read the frequency (which should be the frequency marked on the crystal, i.e., 52.2 megacycles). The stage should oscillate readily with an active crystal; if it does not, reduce the value of the grid resistor until oscillation is obtained. It is not advisable to go lower than 47,000 ohms because too much crystal current flow may cause the crystal to heat and, as a result, drift in frequency.

Remove the milliammeter and solder the 4700-ohm resistor back into the circuit. Insert V5 (7587 quadrupler) into its socket. Apply B+ and couple the grid-dip meter near L_2 and adjust C_4 for maximum output at 208.8 megacycles. Place V6 (6CW4 doubler) into its socket. (This stage may present an adjustment problem because most grid-dip meters used by ham operators do not cover frequencies above 220 megacycles.) If a grid meter is not available to measure 418 megacycles, adjust C_5 for maximum mixer crystal current (1.0 to 1.5 milliamperes maximum).

After a signal generator or antenna system with a characteristic impedance of 50 ohms is connected to the first rf stage and the receiver is tuned to 15 megacycles, tune C_4 and C_5 for maximum noise and crystal current. If the crystal current is more than 1.0 milliampere, bend the injection loop (L_{10}) toward the chassis until the crystal current measures beween 0.6 and 0.8 milliampere. At this time, trim the oscillator-multiplier circuits for maximum noise signal.

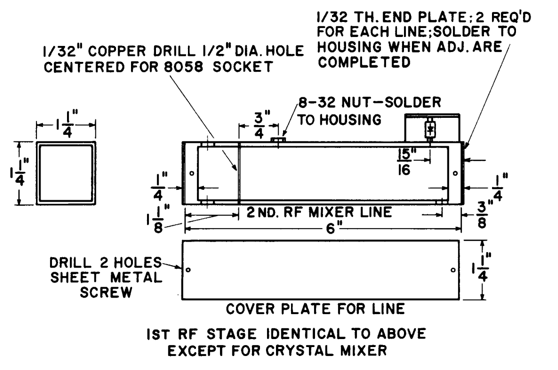


Figure 4: Construction details for two rf amplifiers.

The if amplifier can now be checked for operation and performance. Remove the connection to the crystal and connect a signal generator to the grid of the 7587 mixer. Response should be fairly flat over the 14-to-16-megacycle range. Tuning of the generator over the 14-to-18-megacycle range requires

some peaking of the if coils (L_7, L_8). If no generator is available, noise from the rf amplifier and the mixer can be used to peak the coils.

No oscillation should be observed when a properly matched antenna is connected to the first rf stage and C_1 and C_2 are tuned for maximum noise. If oscillation does occur, the coupling loops (L_{12}, L_{11}) in the rf amplifier probably are coupled too loosely.

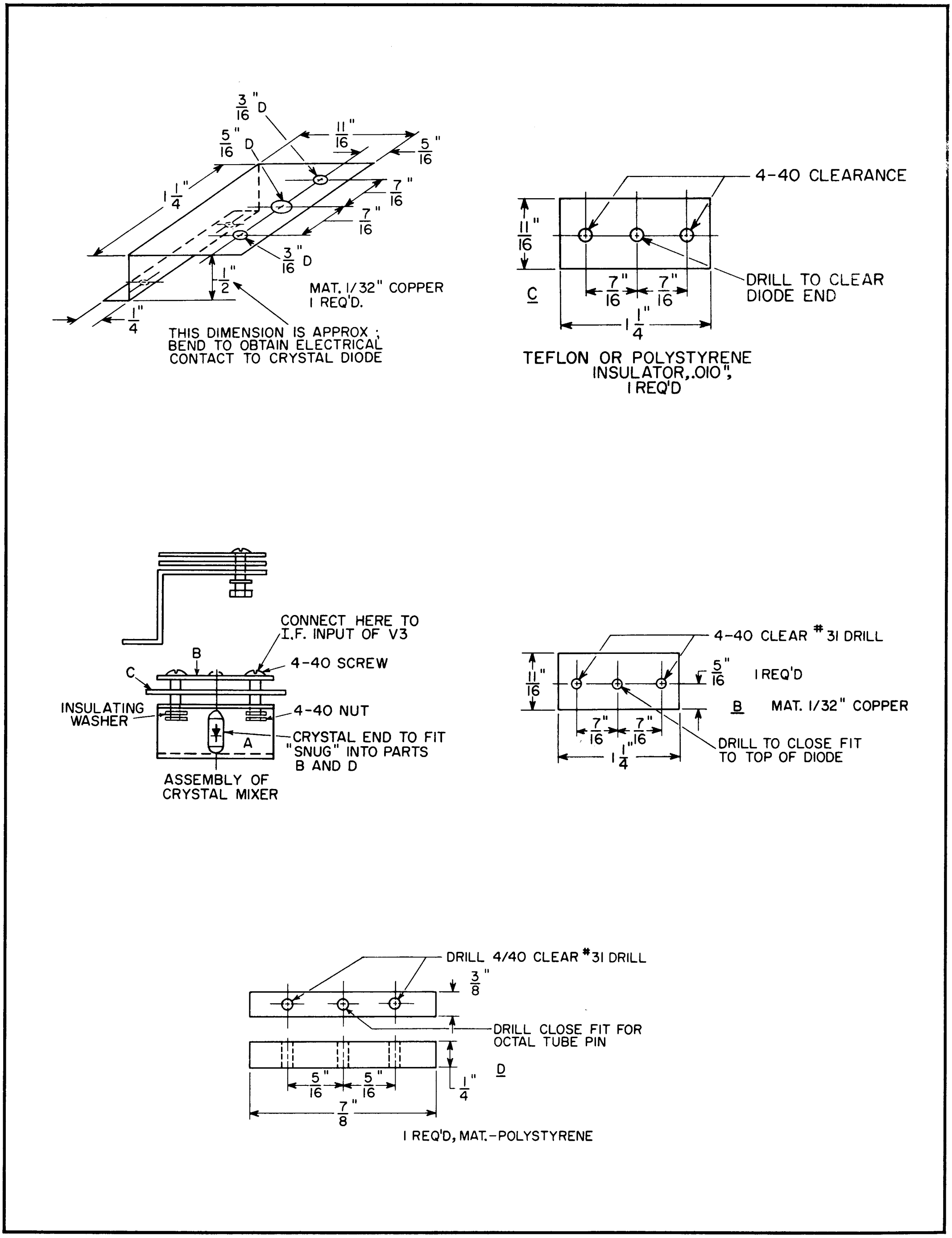
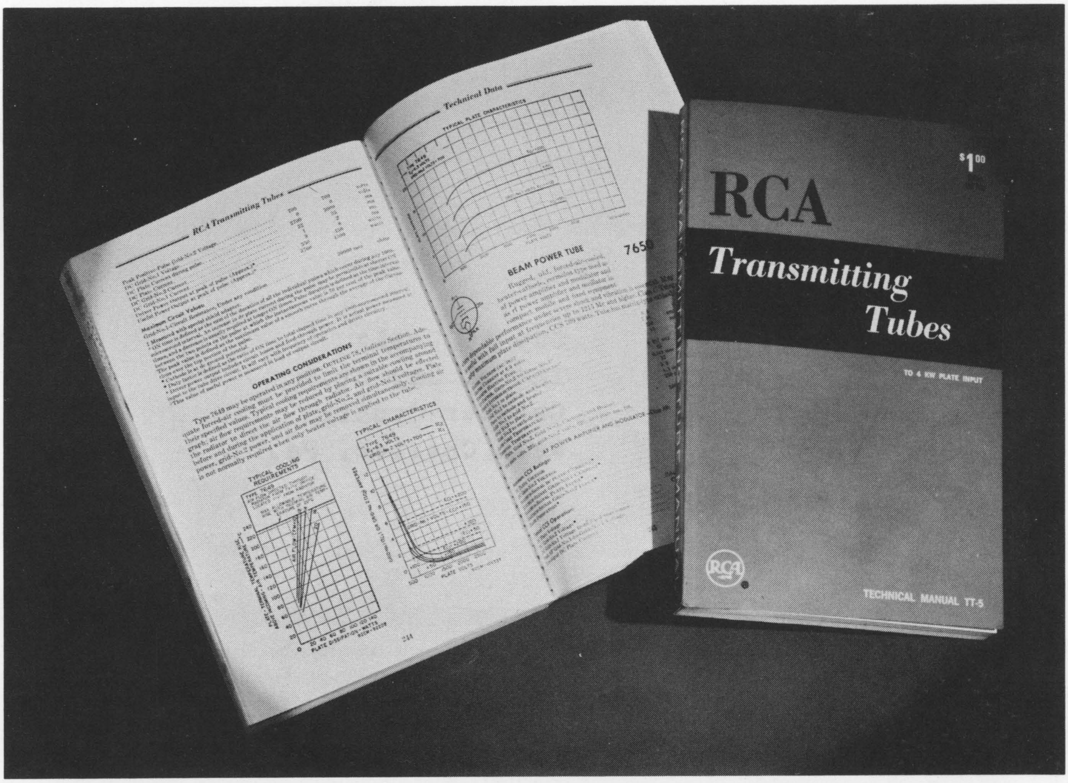


Figure 5: Construction for crystal mixer circuit.



NEW RCA TRANSMITTING TUBE MANUAL TT-5

Every ham will want a copy of RCA's new, 320-page transmitting tube manual. This edition is the largest to date and has been thoroughly revised and updated to keep pace with advances in power-tube technology.

Of tremendous value to radio amateurs, engineers, and others technically concerned with transmitting tubes, the new TT-5 manual provides information for the latest RCA types, including the new cermolox family of ceramic-metal tubes. Coverage of single-sideband information has been considerably increased and includes new single-sideband ratings; discussions of linear power amplifier design; and sample calculations of operating conditions for two-tone modulation.

The popular Circuits Section now contains 23 typical transmitting and industrial circuits. Among these are circuits for a class B linear rf amplifier for single-sideband service; a 120-watt, 50-Mc transmitter; a single-sideband exciter; a 144-to-148 Mc mobile transmitter; and a five-band, 10-to-80 meter transmitter.

In easy-to-understand style, the manual's fully illustrated text material covers power-tube fundamentals, construction, applications, operation and adjustment, and installation—as well as rectifier considerations and interpretations of tube data.

Over 180 types of transmitting tubes and related rectifier tubes are included in the Technical Data Section, which gives maximum ratings, characteristics, typical operating values, and curves.

A reference work that belongs in every ham shack, "RCA Transmitting Tubes" (TT-5) may be obtained from your RCA tube distributor or by sending $1.00 to "Commercial Engineering, RCA Electron Tube Division, Harrison, N. J."

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VOL. 23, NO. 1 WINTER, 1962-63

A MOBILE 50-WATT TRANSMITTER FOR THE SIX- AND TWO-METER BANDS

Part I

By M. R. Adams, WA2ELL, and P. B. Boivin, K2SKK

RCA Electron Tube Division, Harrison, N. J.

A continual increase in the number of technician-class operators is creating new peaks of activity on the six- and two-meter bands. This trend, of course, is most pronounced in metropolitan areas and is evidenced by the quantity and variety of commercial equipment now available for these bands. With the rising popularity of VHF mobile operation, many hams have been seeking new designs to help them achieve higher levels of operating convenience and economy. The use of both six and two meters by Civilian-Defense "RACES" units also makes operation on these bands attractive for emergency use. In a two-part article which will be concluded in the Spring issue, the authors report on a compact, 50-watt amateur mobile transmitter which can be conveniently mounted under an auto dashboard and has a parts-cost which they estimate at no higher than $100. In addition to bandswitching capability for coverage of both six- and two-meter bands, this versatile performer features RCA's recently announced 4604 and 7905 "quick-heating" beam power tube types for added power economy, and incorporates a variable-frequency oscillator—an advantage seldom, if ever, encountered in today's VHF amateur mobile equipment.

The six- and two-meter frequencies are ideal for mobile installations because of the small antenna size and low power needed for good local coverage. However, the higher frequencies in these bands usually require additional tubes for multipliers and drivers. These additional tubes usually increase the standby power drain on the vehicle battery—unless they are the new quick-heating types recently announced by RCA.

The 50-watt transmitter described in this article is a six- and two-meter plate-modulated AM rig using the new RCA-4604 and -7905 quick-heating beam power tubes. With these tubes, you're on the air in less than one second after you press the microphone push-to-talk button! The only standby power needed in the rf section is that for the conventional VFO heater, which is left on for stability. The push-pull plate modulator delivers that "audio punch" that is so essential to mobile operation and not usually found in screen-grid-modulated finals. In addition, the transmitter and modulator package are designed for dashboard mounting for easy accessibility and convenience of operation.

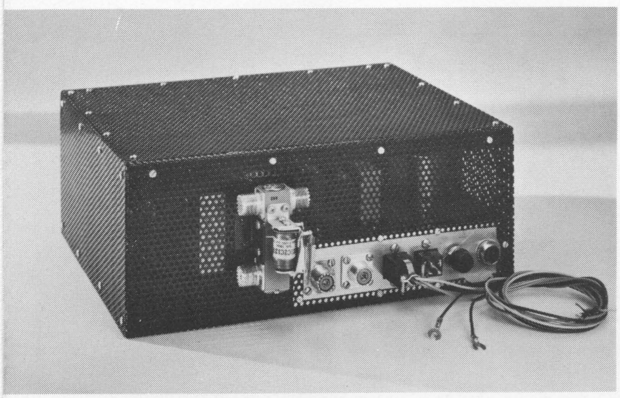
Front view of WA2ELL's and K2SKK's mobile 50-watt transmitter. Unit measures approximately 12 inches in width, 5 inches in height, and 10 inches in depth.

Circuit Description

Switching from the six-meter band to the two-meter band presents some problems not encountered at the lower frequencies. In the final stage, for example, the series-tuned tank circuits must be switched without adding excessive lead length on two meters, and yet some means of coupling to the antenna must be provided. Part of the multiplier string must also be switched out of operation on six meters without disrupting the series-connected heater connections on the quick-heating tubes. These and other problems are resolved in the later discussions.

Variable-Frequency Oscillator

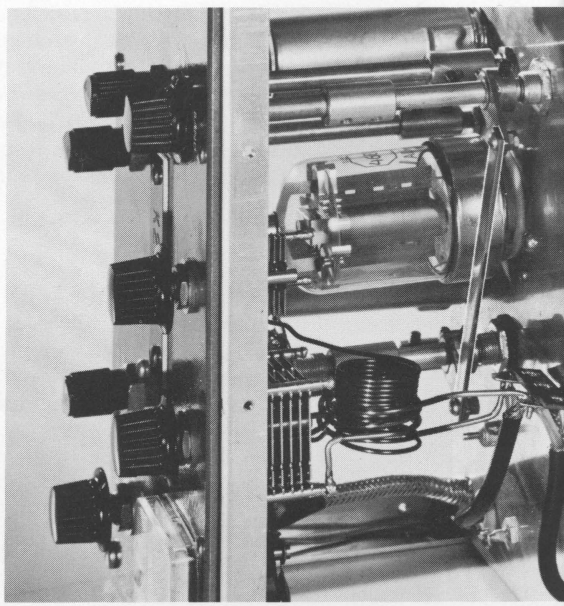
The VFO uses an RCA-6417 miniature beam power tube in a modified series-tuned Clapp oscillator which tunes a basic frequency of 8.0 to 9.0 megacycles. When multiplied, this basic frequency range covers both the six- and two-meter amateur bands. The 8-to-9-megacycle frequency was chosen as the best compromise between stability and a minimum number of multiplier stages. Frequency stability of the VFO is assured by such design features as regulated screen-grid voltage on the 6417, a double bearing VFO capacitor, a ceramic coil form rigidly mounted on the main chassis, and zero-temperature-coefficient (NPO) capacitors. The plate circuit of the VFO doubles the frequency to cover a range of 16 to 18 megacycles. The VFO output is tuned by capacitor C_7 which is controlled from the front panel.



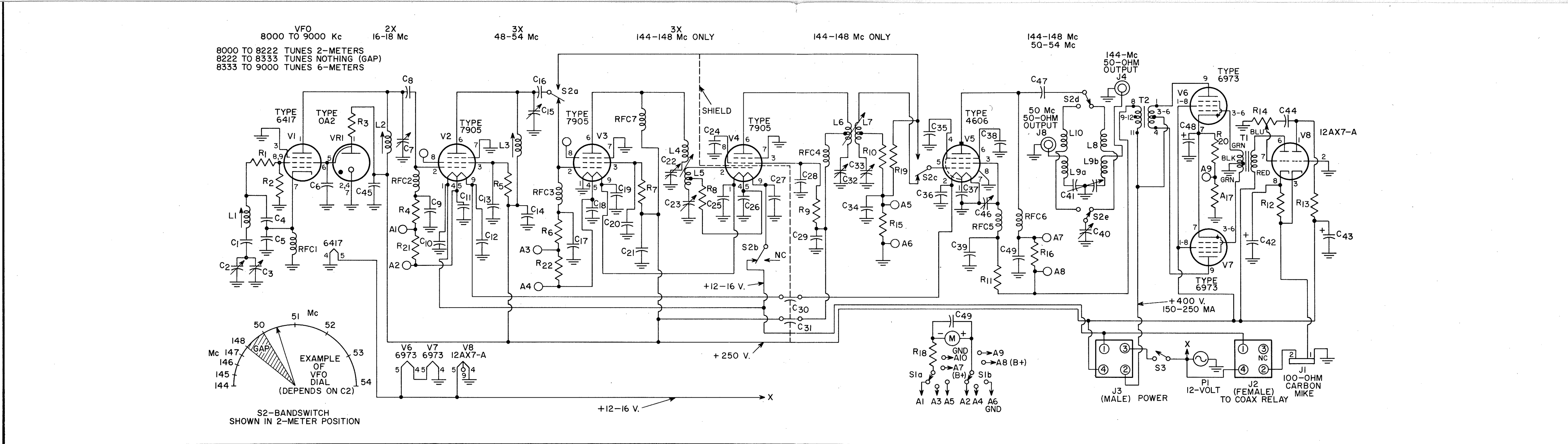
Rear view of new mobile transmitter showing antenna relay, microphone connector, and power connectors.

Multipliers

The VFO is followed by two triplers and a straight-through driver which increase the frequency to 144 megacycles. The circuits for the triplers V2 and V3 are of conventional design and are quite stable if reasonable care is used in wiring (e.g., the use of shortest possible leads for rf wiring and generous by-passing). Front-panel plate tuning is provided by C_{15} and C_{22}. A switch deck (S_{2a} and S_{2b}) located near V2 provides two functions. S_{2a} switches the output of multiplier V2 directly to the final for six-meter operation, or to the next multiplier, V3, for two-meter operation. The six-meter band is covered as the VFO tunes from 8333 to 9000 kilocycles, or the upper two-thirds of the dial. This basic frequency doubles in the plate circuit of V1, then triples in V2 to cover 50 to 54 megacycles. For two-meter operation, the VFO tunes the



Top view of unit showing detail of bandswitch mechanism.



C_1—220 pf, NPO disc ceramic
C_2—5-20 pf, double-bearing variable (Hammarlund MC-20-S or equiv.)
C_3—4-30 pf, NPO ceramic trimmer (Centralab 822-AZ or equiv.)
C_4, C_5—390 pf, silver mica
C_6, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{24}, C_{25}, C_{26}, C_{27}, C_{28}, C_{29}, C_{34}, C_{39}, C_{45}, C_{49}—0.001 μf 600 WV disc ceramic bypass capacitors
C_7, C_{15}—2.3-14.2 pf, Johnson Midget Variables (15M11 160-107 or equiv.)
C_8, C_{16}—100 pf, disc ceramic
C_{22}—1.5-5 pf, Johnson Midget Variable (5M11 160-102 or equiv.)
C_{23}, C_{33}—1-8 pf, Teflon tubular trimmer (Erie 532-10 or equiv.)
C_{30}, C_{31}—0.001 μf ceramic feed-thru (Centralab MFT-100 or equiv.)
C_{32}—2.8-17.5 pf, variable (Johnson Midget 160-107 or equiv.)
C_{35}, C_{36}, C_{37}, C_{38}—0.001 μf button silver mica (Erie 370-FA-102J or equiv.)
C_{40}—3.6-15 pf, double-spaced variable (Hammarlund HF-15-X or equiv.)
C_{41}—6.3-50 pf, 2-section differential variable (Johnson 167-33 or equiv.)
C_{42}—10 μf 50 WV electrolytic
C_{43}—8 μf 450 WV electrolytic
C_{44}—0.01 μf 600 WV paper
C_{46}—5-80 pf, mica trimmer (Arco 462 or equiv.)
C_{47}—0.001 μf 2000 WV transmitting mica
C_{48}—25 μf 50 WV electrolytic
J_1—2-wire & shield microphone jack (Amphenol 80-PC2F or equiv.)
J_2—Cinch-Jones 4-terminal female (261-12-04-010 or equiv.)
J_3—Cinch-Jones 4-terminal male (261-11-04-010 or equiv.)
J_4, J_8—Coaxial cable connector (Amphenol SO-239A or equiv.)
J_5, J_6, J_7—Connectors part of coaxial relay
L_1—32 turns of No. 24 enamelled wire, 11/16-inch long, 1/2-inch ceramic CTC PLS-7-2C4L slug form
L_2—26 turns of No. 28 enamelled wire, 3/8-inch long, 1/4-inch ceramic CTC slug form CTC PLS-6-2C4L
L_3—7 turns of No. 24 enamelled wire, 5/32-inch long, 1/4-inch ceramic CTC slug form CTC PLS-6-2C4L
L_4—4½ turns of No. 18 enamelled wire, 9/16-inch diameter, 1/2-inch long
L_5—4½ turns of No. 18 enamelled wire, 7/16-inch diameter, 3/8-inch long, center-tapped for R_8
L_6—3 turns of No. 20 enamelled wire, 1/2-inch diameter, 3/8-inch long, center-tapped for RFC_4
L_7—3 turns of No. 20 enamelled wire, 1/2-inch diameter, 5/16-inch long, center-tapped for R_{10}
L_8—2 turns of No. 14 enamelled wire, 13/16-inch diameter, 3/8-inch long, wound close-space on 3/4-inch mandrel, released and stretched to length
L_{9a}, L_{9b}—2 turns of No. 14 enamelled wire, 13/16-inch diameter, 3/8-inch long
L_{10}—11 turns of No. 16 enamelled wire, 13/16-inch diameter, close wound 7/8-inch long
M—Meter, 1 ma full-scale
P_1—Microphone plug (Amphenol 80-MC2M or equiv.)
P_2—Cinch-Jones cable clamp (261-11-04-030 or equiv.)
P_3—Cinch-Jones cable clamp (261-12-04-030 or equiv.)
P_4, P_5, P_6, P_7—Coaxial cable connector (Amphenol 83-1SP) (RG-58/U inserts 83-168 3/16-inch)
PL_1—Bayonette pilot bulb socket and red jewel indicator
R_1—68 ohm, ½ watt
R_2, R_{13}—47 K, ½ watt
R_3—5 K, 10 watt, wire-wound
R_4, R_6—56 K, ½ watt
R_5, R_7, R_9—15 K, ½ watt
R_8, R_{10}, R_{19}—18 K, ½ watt
R_{11}—18.5 K, 3 watt (3-56 K, 1 watt in parallel)
R_{12}—1 K, 1 watt
R_{14}—½ megohm potentiometer
R_{15}, R_{21}, R_{22}—470 ohm, ½ watt
R_{16}, R_{17}—10 ohm, ½ watt
R_{18}—1800 ohm, ½ watt
R_{20}—300 ohm, 10 watt
RFC_1, RFC_2, RFC_3—750 microhenry
RFC_4, RFC_6, RFC_7—Ohmite Z-144 or equiv.
RFC_5—Ohmite Z-50 or equiv.
RY_1—Advance coaxial relay, CE/1C2C/12VD (12-volt DC coil and auxiliary contacts)
RY_2—Potter & Brumfield SPST Relay MR3D or equiv.
S_1—DP5T rotary wafer switch, non-shorting (Centralab PA-1003 or equiv.)
S_{2a}, S_{2b}, S_{2c}, S_{2d}, S_{2e}—Centralab SPDT contacts on three separate ceramic wafers (miniatures) SEE TEXT
S_3—SPST toggle switch
T_1—Driver transformer, 10 K plate to PP grids, 3:1 pri. to ½ sec. (Stancor A-4723 or equiv.)
T_2—Modulation transformer, Stancor A-3892 poly-pedance 150 ma
Miscellaneous—Microphone, Astatic Model 10M5A carbon button with PTT switch (or equiv.); National MCN VFO dial

Figure 1: Schematic diagram and parts list of WA2ELL's and K2SKK's low-battery-drain mobile transmitter.

lower one-third of the dial, or 8000 to 8222 kilocycles. This basic frequency is then doubled in the plate circuit of V1 and tripled by V2 to a frequency of 48 to 49.3 megacycles. The output of V2 is switched by S_{2a} to V3 where the frequency is again tripled to cover a range of 144 to 148 megacycles to drive V4, the straight-through driver for the final. In the six-meter position, S_{2b} disconnects the filament power to the two-meter tripler and driver (V3 and V4), which are not used, thereby leaving the filaments of V2 and V5 in series for six-meter operation. (Note that reference is made to "filaments" of the 7905 and 4604 quick-heating tubes. These tubes are filamentary-cathode types and must be treated as such with respect to cathode dc and rf potentials.)

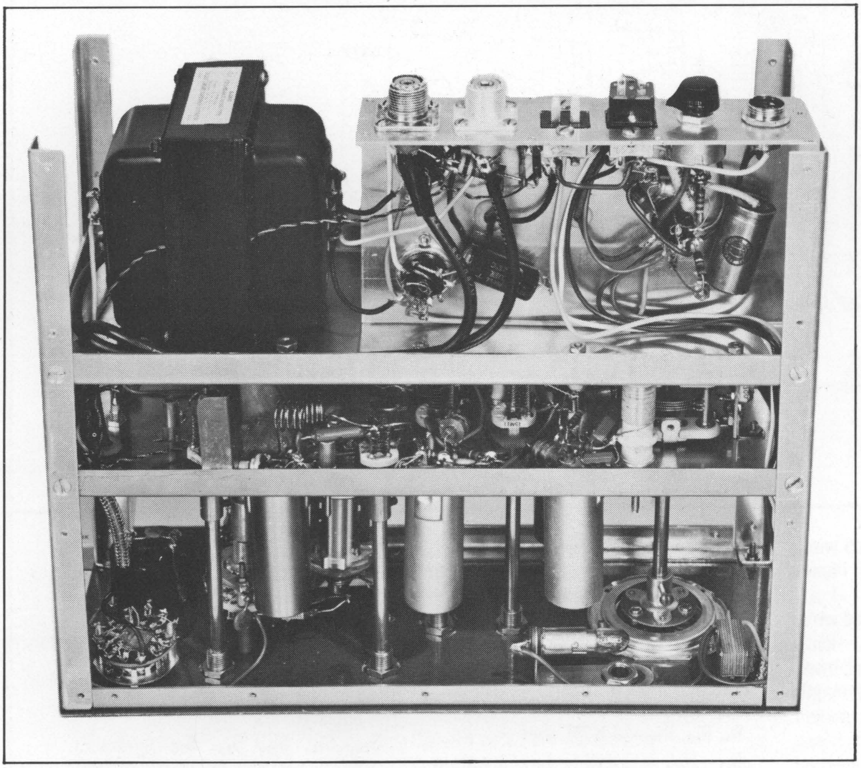
Driver

The driver is a straight-through amplifier which provides adequate power between 144 and 148 megacycles to drive the 4604 final amplifier. The 7905 does not provide sufficient output—when used as a doubler-driver at two-meter frequencies—to drive the 4604 to the required 2 milliamperes grid current. V4 must be shielded across the socket to prevent self-oscillation. The series-tuned circuits in the plate and grid are not switched because they are only used for two-meter operation. Neutralizing should not be necessary when a straddling shield is used across the socket.

Final Amplifier

The final amplifier is a plate-modulated single-ended stage utilizing the RCA-4604, which is similar in ratings to the popular 6146. The 4604 uses directly heated filaments for the quick-heating feature. From a cold start, this tube and the 7905 drivers and multipliers reach approximately 90% power output within one second after application of filament voltage. The filament is specifically designed to withstand the normal voltage variations encountered in mobile use. The grid circuit is series-tuned for two meters and sufficient reserve drive is available from V2 to utilize an untuned grid-No. 1 circuit on six meters. This arrangement simplifies the switching and reduces the number of components required.

The plate circuit is series-tuned on both six- and two-meter bands. One tuning capacitor (C_{40}) is switched from one tank coil to the other by one bandswitch deck. Two separate links (L_{9a} and L_{9b}) are used in conjunction with two separate antenna SO-239 jacks at the rear of the transmitter. Each separate link is series-tuned by one-half of a two-section



Bottom view showing modulator construction and rf section.

differential capacitor (C_{41}) which is used for antenna loading. This arrangement permits the combination of two functions in one front-panel control. Separate antenna jacks are feasible because the same mobile antenna is rarely used on both six- and two-meter bands. The 4604 is neutralized by a tuned screen-grid network (RFC_5 and C_{46}).

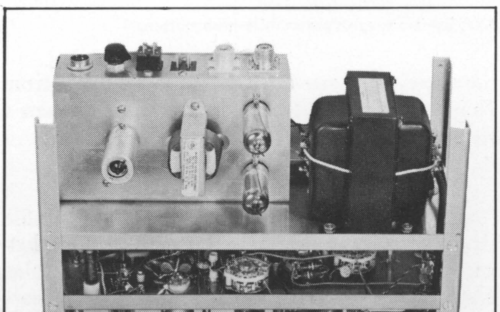
Modulators

The RCA-6973 modulators deliver 20 watts of peak power for plate modulation of the final. At the low voltages used in this transmitter, this output is adequate for 100% modulation. Cathode bias in the modulator eliminates the need for a negative fixed-bias supply —an important feature because this type of supply is not always readily available in mobile installations. The speech amplifier (V8) is designed for a high-output carbon microphone. (A crystal microphone would require an additional triode for amplification ahead of V8.) The speech-amplifier-and-modulator circuit is conventional and requires no special precautions in wiring. Because the 6973's become hot in operation, they should not be covered by a tube shield. A clip should be used to hold the tubes in the sockets. V8 requires a conventional tube shield.

Metering

A five-position switch (S_1) is used with a 0-1 milliampere meter to read final plate and grid currents, modulator cathode current, and multiplier grid currents. The value of the series-multiplier resistor (R_{18}) depends on the internal resistance of the meter and the full-scale sensitivity desired. The arrange-

Top view of 50-watt bandswitching transmitter showing modulator layout and final tank-circuit components.



ment used in this transmitter utilizes the meter as a voltmeter to measure the voltage drop across resistors in series with the plate circuit in each stage. In this way, circuit disturbance is kept to a minimum since the metering resistors are always in the circuit. The values in this circuit provide a full-scale sensitivity of 200 milliamperes for plate-current readings and 2 milliamperes for grid-current readings. Both legs of the meter circuit are switched together because there is B+ voltage on both sides of the metering resistor in some positions. The switch itself is mounted on the chassis and is operated by a shaft extending to the front panel. This arrangement keeps leads to the switch short and prevents stray coupling to the final tank coils, so that the possibility of parasitic oscillations is minimized.

Transmitter Power Requirements

The transmitter-modulator combination is designed to operate from a supply that delivers approximately 300 milliamperes at 400 volts and 200 milliamperes at 250 volts, or a total of approximately 170 watts. Because the final and modulator use 400 volts B+, two separate high-voltage supplies are not needed. The total standby power required from the 12-volt dc supply is one ampere when the unit is turned on; during transmission, a current of 1.85 amperes is required on six meters or 2.5 amperes on two meters. The B+ supply requirements depend on the type of supply used and its conversion efficiency. The actual current drawn by the transmitter at 400 volts is 215 milliamperes with no modulation; however, the power supply must deliver peak currents of up to 300 milliamperes when the final is modulated. The authors use dynamotors already on hand to power this unit. Dynamotors are readily available at very moderate cost from military-surplus jobbers.

Auxiliary Antenna and Receiver Switching

During transmit periods, a coaxial relay RY_1 on the rear of the transmitter can be used to mute the receiver as well as switch the antenna lead-in between transmitter and receiver. This relay is operated by the push-to-talk switch on the microphone. Because there are separate jacks for six- and two-meter antennas on the rear of the transmitter, a short piece of coaxial cable must be used between either one of these jacks and the transmitter side of the coaxial relay. This jumper, as well as the antenna, must be changed when bands are changed. RG-58/U, 50-ohm coaxial cable is usually preferred for mobile work. Should the builder desire further flexibility, another coaxial relay can be utilized externally to perform the function of switching the jumper.

HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. 23, NO. 2

SPRING, 1963

A MOBILE 50-WATT TRANSMITTER FOR THE SIX- AND TWO-METER BANDS

Part II

By M. R. Adams, WA2ELL, and P. B. Boivin, K2SKK

RCA Electron Tube Division, Harrison, N. J.

The Winter, 1962-1963, issue of HAM TIPS presented the first installment of a two-part article on a compact, mobile-type 50-watt amateur bandswitching transmitter designed for coverage of the six- and two-meter bands and employing RCA "quick-heating" tube types 4604 and 7905 for added power economy. In that issue, the authors covered such considerations as circuit description, variable-frequency oscillator, multipliers, driver, final amplifier, modulators, metering, transmitter power requirements, and auxiliary antenna and receiver switching. The article is now concluded with a discussion of chassis construction and layout, bandswitching details, capacitor-mounting details, VFO design, driver shielding and construction details, final-amplifier layout, modulator details, VFO calibration and alignment, alignment procedure for multipliers and driver, and general conclusions and installation tips.

Front view of WA2ELL's and K2SKK's mobile 50-watt transmitter. Unit measures approximately 12 inches in width, 5 inches in height, and 10 inches in depth.

Chassis Construction and Layout

Templates for the chassis layout are shown in Figures 3, 4, and 5. The main chassis is made of 20-gauge sheet brass to facilitate ground connections. The socket straddle shield for V4 is fabricated from 24-gauge copper. Aluminum angle stock ($\frac{1}{2}$-inch by $\frac{1}{2}$-inch) is cut and drilled to tie together the front panel, main chassis, and modulator. Two more pieces of aluminum angle, $\frac{3}{8}$-inch by $\frac{3}{8}$-inch, are attached to the top and bottom edges of the front panel to hold the cover. This type of construction results in a finished unit which can be dash-mounted and requires minimum space in the front seat of the vehicle. The use of a perforated sheet-steel cover, which is mounted in two halves, provides easy

access for servicing and allows air to circulate freely. The front panel is fabricated from ⅛-inch sheet aluminum. The modulator is a simple channel-shaped chassis cut down from commercially available chassis or constructed from 1/16-inch sheet aluminum as shown in Figure 5. The meter hole in the front panel should be cut with a hole cutter in a drill press. (A chassis punch may warp the panel.) All other large holes can be punched with standard chassis punches.

Bandswitching Details

Bandswitching is accomplished by means of a single knob on the front panel. Figure 6 shows the mechanical linkage for this control which operates S_{2a} directly on the main chassis. The steel ball in this deck provides the detent action for all three switches. A crank on the S_{2a} shaft operates a connector bar which fastens to a similar crank on the common shaft of S_{2c} and S_{2e}. The ball detents in these two ganged switches are removed to decrease the mechanical resistance on the connector bar and at the knob on the front panel. The ganged decks are held in position by the connector bar. An end-to-end shaft-extension coupling having two set screws is available at most parts-suppliers and can be cut in half to make the two cranks for the connector bar. Because the couplings are usually nickel-plated brass, a small 1/16-inch sheet-brass tab can be soldered to the end of the coupling to form a crank and to operate the connecting bar (see Figure 6). The nickel plating should be filed off the end to permit soldering.

The deck with S_{2d} and S_{2e} is back-mounted to the rear of the front panel by the two screws that hold the wafer to the switch, rather than by the shaft. Longer, 4-40 machine screws are used, along with two standard ¾-inch spacers which are cut down to ⅝-inch. *Care must be taken to line up the front panel and main chassis so that the switch shafts do not bind or place undue pressure on the ceramic wafer sections.* Remember that the S_{2e} section is wired backwards because it turns in the opposite direction to S_{2d}. Because of the close spacing between terminals on these switches, unused contacts which are adjacent to terminals with high rf voltage should be removed by carefully drilling out the rivets. This step is necessary to prevent breakdown and to decrease circuit capacitance. To prevent stray 50-megacycle rf from feeding through to the final, the terminal on S_{2a} which connects to the grid of the final amplifier is grounded when the switch is in the two-meter position. All shaft couplings on this switch should have flats filed on the shaft under the set-screws to maintain proper alignment and indexing on all three decks.

MODIFICATIONS: In the Part I, Page 5, photograph (Winter, 1962-63, issue) showing modulator construction and rf section, the meter switch, S_1, is shown mounted on the front panel. The authors subsequently modified the transmitter to mount S_1 on the rf chassis with a shaft extension to the front panel, as described in the text. The main rf chassis template (Part II, Figure 4) includes this modification. The modification was made to prevent the meter leads from picking up stray rf from the final tank coil. Also note that in the Part I, Figure 1 schematic diagram, the final amplifier, V5, is incorrectly labeled as 4606 rather than 4604 as described in the text. Also, VFO tube V1 shows the junction of R_1 and R_2 incorrectly connected to the screen grid rather than to the control grid (pins 8 and 9). Multiplier V3 shows pin 8 incorrectly connected to the suppressor grid rather than to its screen grid. On both V2 and V3, socket pin 8 should be tied to pin 3 with a short jumper. Resistor R_{17} is incorrectly shown as A_{17}. Switch S_1 in Parts List (S_{1a} and S_{1b} in schematic diagram) is actually a two-pole, single-wafer, five-position rotary. The ceramic switches (Parts List designations S_{2a}, S_{2b}, S_{2c}, S_{2d}, and S_{2e}) are three Centralab miniature type PA-2007's—modified as described in the text.

Capacitor-Mounting Details

Tuning capacitors C_7, C_{15}, C_{22}, and C_{32} are Johnson midget variable capacitors which mount in a ¼-inch hole and have a 3/16-inch-diameter slotted shaft for screwdriver adjustment. These capacitors can be adapted to front-panel tuning by using 3/16-inch shaft couplings and extensions. Because these items of hardware are often difficult to obtain, 3/16-inch-to-¼-inch shaft adapters can be used which will allow standard ¼-inch hardware to be used on the front panel. It is suggested that oversized holes be used in the front panel to facilitate proper alignment of switch and capacitor shafts during assembly.

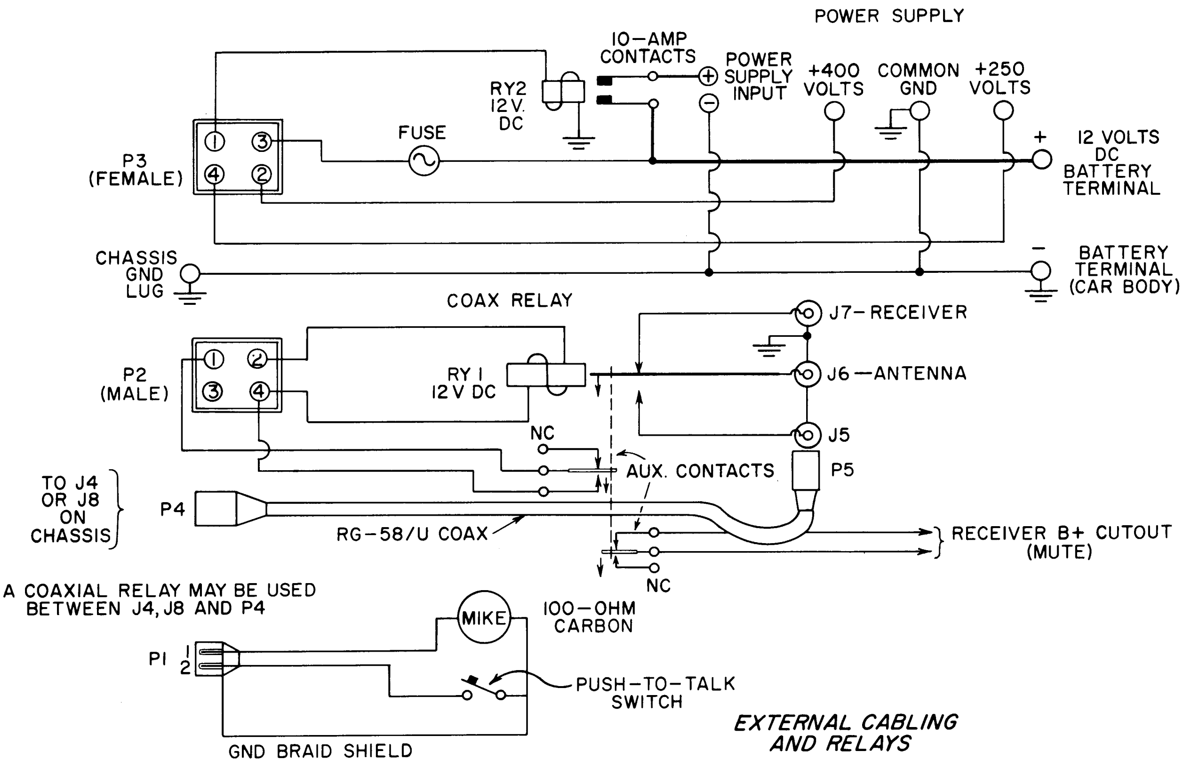


Figure 2: Suggested cabling diagram.

VFO Design

The VFO components should be mounted as rigidly as possible. Care in this respect results in mechanical stability and freedom from FM caused by vibration. The VFO dial calibration favors six meters because the authors planned to use this band most frequently. Some constructors may prefer to add an additional switch in the VFO and two separate capacitors, thus allowing each band to be spread across the dial for easier tuning. Admittedly, crystal control is more stable for mobile operation; however, it is the authors' experience that once a VFO is available, crystals are seldom used. The flexibility of a VFO more than compensates for any difficulty that might be encountered (e.g., drifting out of the narrow passband of certain VHF converters). As a result, the crystal socket, mode switch, extra components, etc., are left out to save space and simplify construction.

Driver Shielding and Construction Details

Because tube V4 operates as a straight-through amplifier at 144 megacycles, adequate isolation between input and output circuits must be provided to prevent oscillation. Neutralization was not necessary with a straddle-shield across the socket to shield the plate-circuit components from the input coils. Oscillation could be a problem with variations in design; therefore, certain units may require neutralization. The shield used in this transmitter is fashioned from tinned-copper flashing and soldered in place so that socket pins 1, 2, and 3 are on the input side and the remainder of the pins are on the output, or plate-circuit, side. If the nine-pin socket has a center lug, it should be soldered to the shield. The size of the shield should be sufficient to separate coils and components as well as socket pins (see Part I photograph showing top view of transmitter and modulator layout and final tank-circuit components).

Final-Amplifier Layout

The grid-No. 1 wiring for final stage must be as close as possible to the bandswitch S_{2c} to keep lead length to a minimum. Bypass capacitors (C_{35}, C_{36}, C_{37}, and C_{38}) in the final are the chassis-mounted, ceramic-button-stand-off type which mount with a 3-48 machine screw. This type of capacitor provides excellent rf grounding with an octal socket. Grid coils for the two-meter band are mounted directly on the bandswitch contacts. The grid-leak bias resistors (R_{10} and R_{19}) are soldered directly to the chassis and as near the V5 socket as possible. The screen-grid neutralizing capacitor C_{46} is an Arco mica compression type and may be rigidly mounted directly across the V5 socket between pins 3 and 7. Plate-circuit components are switched by S_{2d} and S_{2e}. Again, short leads are essential on two meters. The switch-contacts support the tank coils and associated link-coupling coils L_{9a} and L_{9b}. RG-58/U coaxial cable couples directly to each link and carries the output through the main chassis and modulator panels to two separate SO-239 connectors on the rear apron of the modulator. Because these connectors are close to the audio speech amplifier, "hoods" are used to shield the connectors; rf feedback at this point could cause oscillation. The plate-tuning and antenna-loading capacitors are both mounted on the front panel, as well as switch deck S_{2d} and S_{2e}.

Modulator Details

The modulator is conventional and needs only a few comments other than what has already been outlined. Because the microphone connector and audio-gain control are both mounted on the rear apron, input leads to the speech amplifier (V8) are short. Once the audio gain is adjusted for a particular microphone, it is usually unnecessary to change it unless a different microphone is used.

The modulator panel is the same size as the main RF chassis and fastens to the angle brackets to complete the assembly. The preamplifier chassis and modulation transformer are then mounted to this panel. External power supply and antenna connectors are mounted on the modulator chassis. The antenna-switching coaxial relay is mounted on the rear of the punched-steel cover. A jumper lead completes the connection to the transmitter. Auxiliary contacts on the coaxial antenna relay are used to energize the quick-heating filament string in the rf chassis.

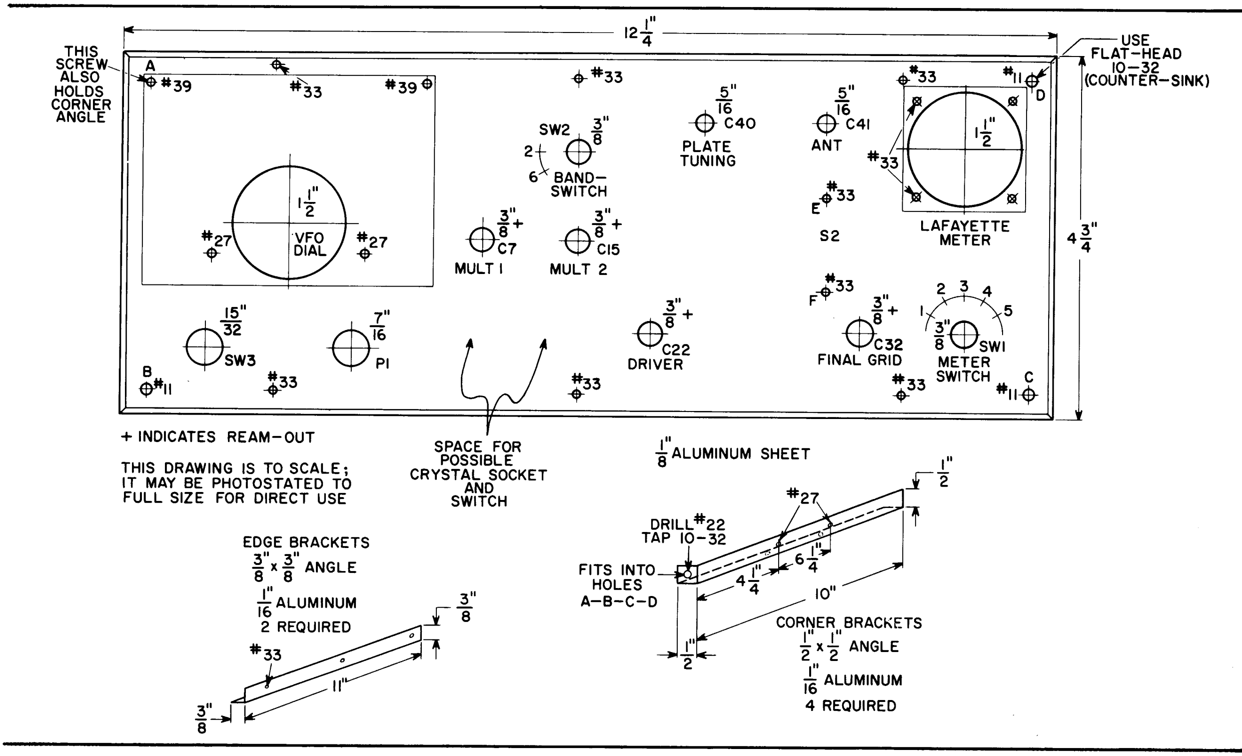
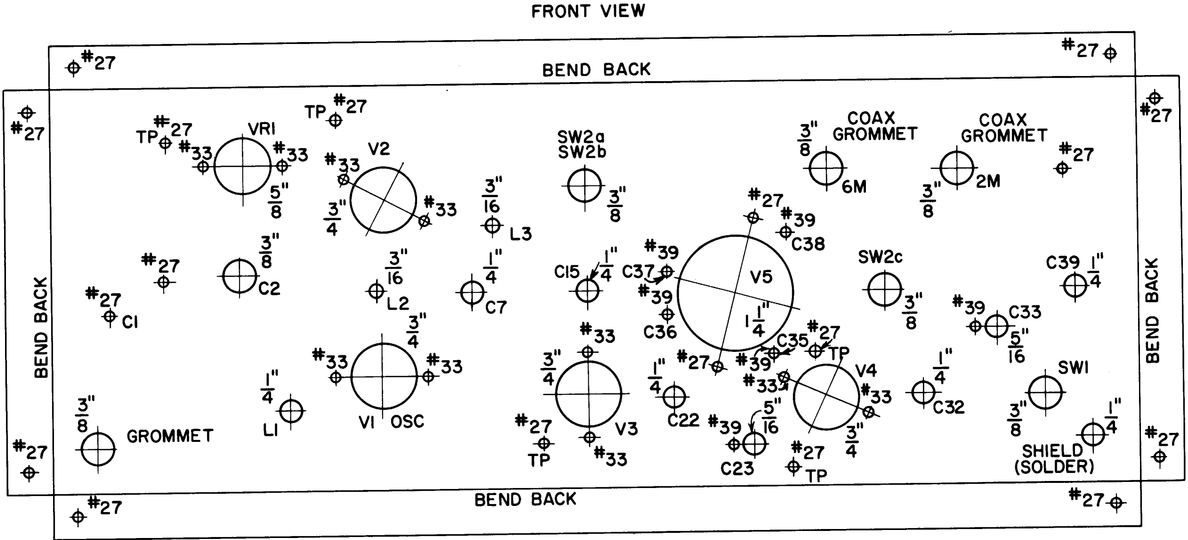


Figure 3: Construction details for front-panel template.



20-GAUGE BRASS TP= TIE POINT

THIS DRAWING IS TO SCALE; IT MAY BE PHOTOSTATED TO FULL SIZE FOR DIRECT USE

Figure 4: Construction details for main-chassis template.

VFO Calibration and Alignment

The VFO is calibrated from 8.0 to 9.0 megacycles with the aid of a BC-221 frequency meter or a good receiver with a crystal calibrator. The upper two-thirds of the dial scale is numbered with six-meter frequencies which correspond to the sixth harmonic of the basic VFO frequency (50 megacycles is the sixth harmonic of 8333 kilocycles). The lower third of the dial is numbered with two-meter frequencies which correspond to the eighteenth harmonic of the basic VFO frequency (145 megacycles is the eighteenth harmonic of 8055 kilocycles). Subdivisions of each band are placed at half-megacycle intervals.

When the VFO is being aligned, C_2 and C_3 are set at maximum capacitance and the slug in L_1 is tuned until the 8.0-megacycle beat note is heard on the BC-221. C_2 is then tuned to minimum capacitance and checked against the 9.0-megacycle beat note. If the 9.0-megacycle beat is not heard, C_3 is trimmed until it can be heard. C_2 should then be returned to maximum capacitance and the slug in L_1 retrimmed for the 8.0-megacycle beat. This procedure must be repeated several times to find a combination of L_1 and C_3 which covers the 8.0-to-9.0-megacycle range with maximum utilization of dial scale space. It should be remembered that, in aligning any VFO, the trimmer capacitors are always adjusted at the highest frequency on the dial and the coil slugs are adjusted at the lowest frequency on the dial.

Alignment Procedure for the Multipliers And Driver

When the VFO has been aligned and the power connections to the transmitter completed, the following steps should be followed to tune and align the multipliers and the driver:

1. Remove modulator tubes and disconnect the 400-volt B+ supply *only;* the 250-volt B+ supply is needed for this portion of the line-up.
2. Set band switch to six meters.
3. Set VFO to 51 megacycles on the dial.
4. Set capacitor C_7 to half-open.
5. With meter switch in position 1, adjust L_2 for maximum grid drive.
6. Set capacitor C_{15} to its half-open position.
7. Place meter switch in position 3 and adjust L_3 for maximum drive at 51 megacycles.

This step completes the alignment for six meters. In future use, the transmitter is tuned up on six meters merely by setting the VFO to the desired frequency and then tuning capacitors C_7 and C_{15} for maximum grid-No. 1 drive. The final stage may then be tuned for maximum output as indicated in steps number 13 and 14 which follow.

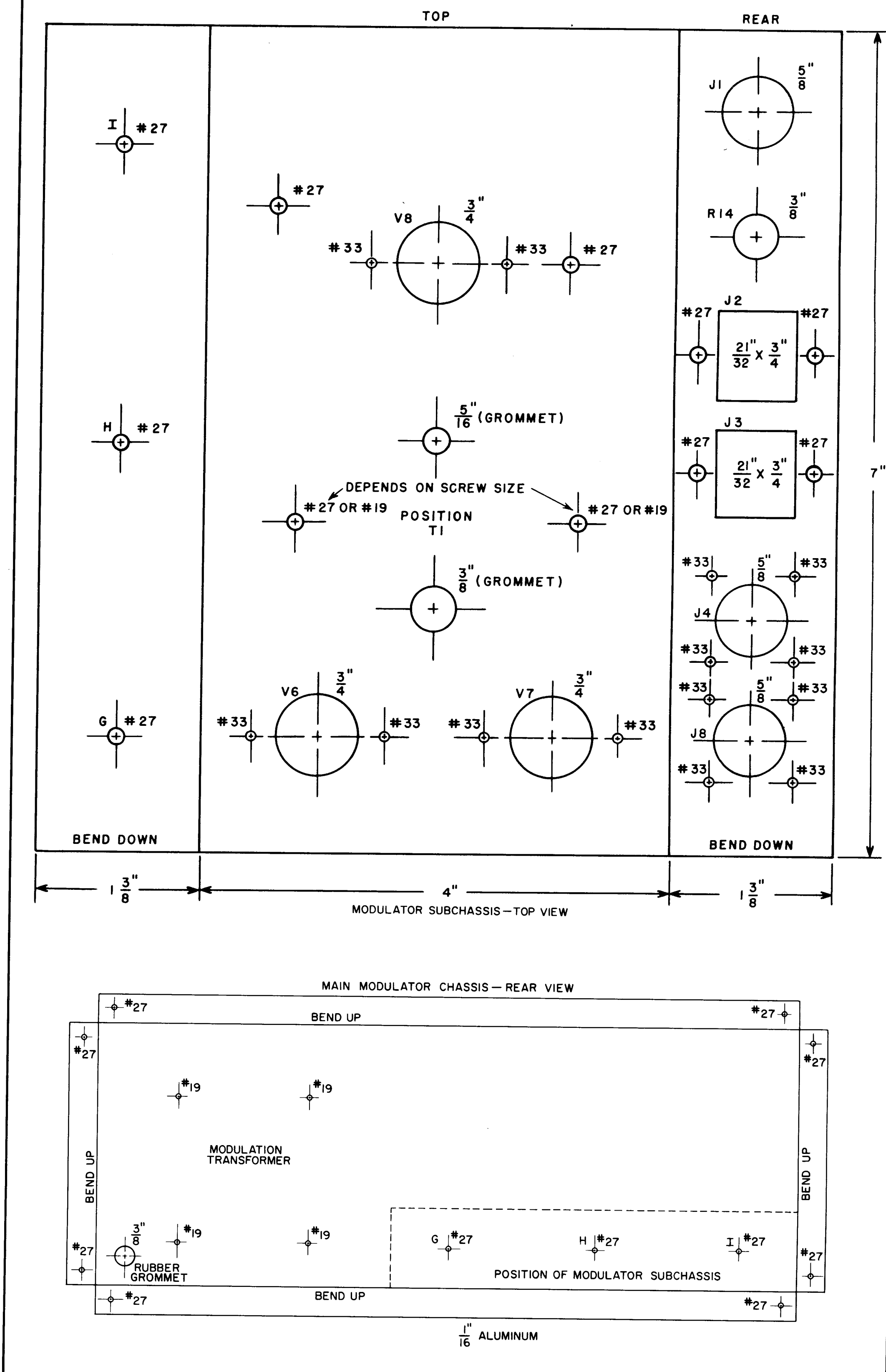


Figure 5: Construction details for modulator template (2 parts).

The alignment of the two-meter section of the transmitter is accomplished as follows:

1. Set the bandswitch to the two-meter position.
2. Set the VFO to 145.5 megacycles on the dial.
3. Peak capacitor C_7 for maximum output on the meter in position 1.
4. Peak capacitor C_{15} for maximum output with the meter in position 2.
5. Set capacitor C_{22} to its half-capacitance position.
6. Set capacitor C_{23} to half-capacitance (brass slug half out of the cylinder).
7. "Squeeze" coils L_4 and L_5 and adjust C_{23} to obtain maximum drive with the meter in position 3.
8. If there is no meter indication, adjust C_{32} until some drive is obtained, then return to step No. 7, above.
9. Set capacitor C_{33} to its half-capacitance point as in step No. 6.
10. Set C_{32} to its half-open position.
11. "Squeeze" coils L_6 and L_7 and adjust C_{33} for maximum output.
12. Adjust capacitor C_{46} (screen-grid neutralizing capacitor) for minimum change in drive as the plate tuning capacitor (C_{40}) is tuned back and forth through resonance.
13. Connect the 400-volt B+ supply; plug in the modulator tubes; and connect a dummy, non-inductive load to the two-meter antenna jack.
14. With the meter in position 4, turn on the transmitter and tune C_{40} for the resonance dip. Load the dummy load with C_{41} so the dip in plate current occurs at 150 milliamperes. This value should be the maximum plate current used. Recheck grid drive to the final and readjust C_{32} if necessary.
15. As C_{40} is rocked through resonance, recheck the neutralizing capacitor C_{46} for minimum *change* in grid drive to the 4604. Meter should be in position 3.
16. Switch the meter to position 5 and check modulator current. Modulator should idle at approximately 55 milliamperes and peak up to 125 milliamperes with voice modulation.
17. The antenna link positioning should be adjusted if capacitor C_{41} does not pass sufficient power to the load. The output into a 50-ohm non-inductive load, with 1:1 SWR should be approximately 20 watts at 145 megacycles and 30 watts at 51 megacycles.
18. Turn off the transmitter. Switch to six meters. Turn on the transmitter and tune up on 51 megacycles. No change in neutralizing should be required on the 4604 final.

When tuning the transmitter on the two-meter band, set the VFO to the desired frequency, then tune C_7, C_{15}, and C_{32} for maximum indication on the meter in respective positions 1, 2, and 3. With the meter in position 4, tune C_{40} for resonance and C_{41} for maximum power into the antenna.

As with any antenna fed from a transmitter link, the SWR should not be allowed to get too high (over 2:1) or it will be impossible to tune the transmitter properly. Link tuning is different from pi-net loading, which can usually couple appreciable power into a transmission line with a high SWR.

In all the above adjustments, it is necessary to have either a microphone in the carbon-mike socket or a switch in the proper J_1 termi-

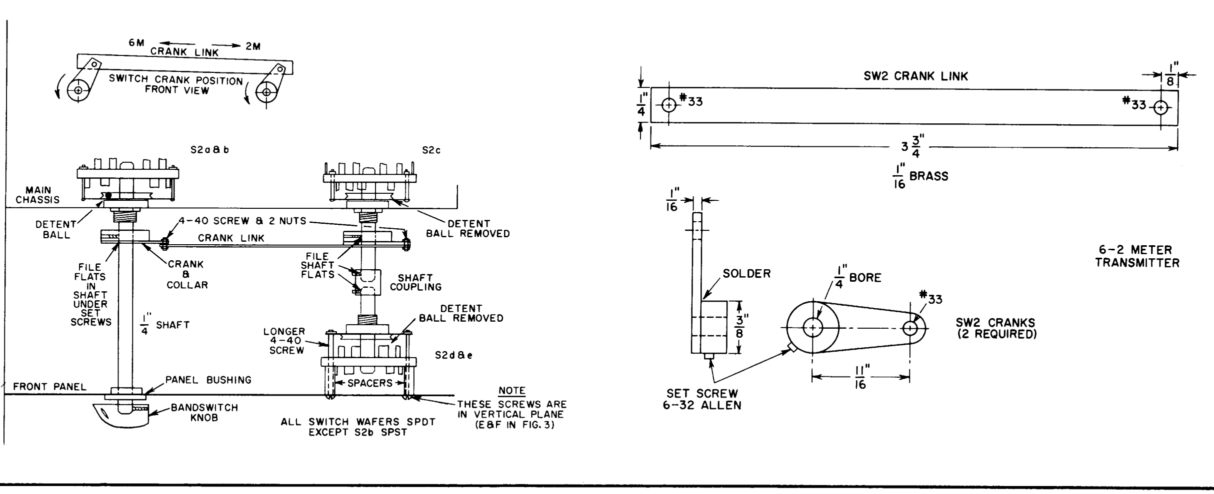


Figure 6: Detail of switches S_{2a}, S_{2b}, S_{2c}, S_{2d}, and S_{2e} (2 parts).

nals to turn the transmitter and quick-heating tube filaments on and off.

Conclusions and Installation Tips

The output section of this transmitter is designed to operate into a 50-ohm coaxial transmission line. Because of its small size, RG-58-U is ideal for mobile installation. A quarter-wave whip or combination coaxial antenna can be used with excellent results, although many amateurs today prefer horizontal polarization for mobile work. The coaxial relay switches the 50-ohm line from the antenna to either the receiver or transmitter and permits single-button, push-to-talk operation while the vehicle is in motion. As shown in Figure 2, pin No. 1 on P_3 is wired to energize a relay with heavier contacts which turns on the high-voltage power supply. Additional suggested power supply and antenna connections are shown in Figure 2.

The final amplifier could be operated with a combination of fixed negative bias and developed bias from drive. Under these conditions, the fixed bias would prevent the 4604 from exceeding rated plate dissipation in the event grid drive were lost. The fixed-bias feature is not incorporated in this transmitter because a negative supply was not available from the authors' dynamotor power supply.

Sufficient room is available on the front panel for an additional switch and crystal socket. If this feature is added, a crystal-controlled oscillator may be used in place of the VFO, as mentioned earlier in this article. The oscillator can be a 7905 quick-heating tube which would result in zero-standby power for the rf section. A 10-ohm resistor would have to be used in series with the 6-volt 7905 filament for 12-volt operation. This low-drain feature, plus crystal control, should be ideal for six- or two-meter CD work where portable power is at a premium. If such a 7905 crystal oscillator is employed, fixed bias on the 4604 is mandatory to protect the tube during the time the oscillator comes on.

Lower standby power could be obtained by substitution of a transistorized modulator, however, the tube modulator is less costly because of the higher cost of comparable transistors. A dynamotor power supply would be less costly than a transistorized power supply, especially because of the availability of war-surplus units.

The individual constructor may wish to incorporate his own variations in design, depending on personal preferences. This article shows what can be done with the new line of quick-heating transmitting electron tubes in mobile work—tubes made by RCA which offer the "mobiler" more VHF output power per dollar than any present-day semiconductor device!

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HAM TIPS

A PUBLICATION OF RCA ELECTRONIC COMPONENTS AND DEVICES

VOL. 23, NO. 3

SUMMER, 1963

HAM-BAND CHARTS

Covering FCC Allocations From 1.8 to 450 Megacycles

By L. W. Aurick, K3QAX/W2QEX

RCA Electronic Components and Devices, Lancaster, Pa.

The Federal Communications Commission requires hams to be familiar with all frequency assignments for amateur operation. If you have been searching for a way to keep informed on the various types of emissions authorized on the 10 amateur bands from 1.8 to 450 megacycles, try posting the accompanying charts near your rig.

For sake of brevity, these charts cover only the bands up to 450 Mc, which represent the areas of operation for most hams. Amateur bands above this frequency include the ranges from 1215-1300 Mc, 2300-2450 Mc, 3300-3500 Mc, 5650-5925 Mc, 10,000-10,500 Mc, 21,000-22,000 Mc, and all frequencies from 40,000 Mc upwards. Hams interested in any of the latter frequency assignments should consult the FCC Rules and Regulations, Part 12, Amateur Radio Service, for available operating privileges.

Chart 1 will take a lot of the guesswork out of your low-frequency operation and can be used for quick selection of crystals or VFO frequencies for harmonic functions. Amateur bands from 160 to 10 meters are shown, as well as their harmonic relationships and authorized amateur emissions. Each line contains the symbols for the types of emissions authorized between the two frequencies shown.

The following examples illustrate the use of Chart 1:

(a) As indicated, your favorite 7.140-Mc "rock" can be a mighty useful item if you decide to invade 20-, 15-, or 10-meter 'phone. With suitable multiplier stages, you can be on 14.280, 21.420, or 28.560 Mc.

(b) This example concerns the use of a 3.55-Mc crystal on the higher frequency 'phone bands. Because it is right on the edge for 20-meter 'phone, it is not suitable there, but operates nicely 50 kilocycles "in" on 15 meters. If you can stand the QRM from the kilowatt signals, there is nothing else to worry about.

Chart 1 also can be used to determine the ranges to be covered by intermediate buffer and frequency multiplier stages.

It should be pointed out that the chart shows amateur bands in their *relative* harmonic sizes. Actually, the 10-meter band is nearly four times the size of the 80-meter band in assigned kilocycles.

Chart 2 shows assignments in the four lowest VHF bands. These bands are not directly harmonically related. At a glance, it can be seen that 50.10 Mc is the lowest frequency at which either tone-modulated keying (except for voice-interrupted code practice) or facsimile modulation is permitted. Likewise, 51.00 Mc is the lowest frequency at which an unmodulated carrier can be transmitted for other than short periods of testing.

At 52.50 Mc, the FCC begins to remove limitations. Above this frequency, amateurs may use most of the authorized wide-band frequency modulated emissions. Above 220 Mc, there are no sub-allocations. Any type of emission, including telegraphy and telephony,

authorized to be used in either the 1.4- or 0.7-meter band, may be employed throughout each band. It is worthy of note that A5 modulation appears to be growing in popularity, with a number of determined amateurs operating between 420 and 450 Mc—the lowest-frequency amateur band in which television is permitted.

The "Index to Symbols Used in Charts 1 and 2" lists all emissions authorized for use by amateurs through 450 Mc. Wide-band modulation is implied in all listings for the "Frequency (or Phase) Modulated" section. However, only in the 10-meter band (between 29.00 and 29.70 Mc) may wide-band F3

INDEX TO SYMBOLS USED IN CHARTS 1 AND 2

Showing All Emissions Authorized for Use By Amateurs Through 450 Mc

Type of Modulation Or Emission	Type of Transmission	Symbol
Amplitude Modulated	Absence of Any Modulation	AØ
	Telegraphy (On-Off Keying)	A1
	Telegraphy (Tone Modulated)	A2
	Telephony	A3
	Facsimile	A4
	Television	A5
Frequency (Or Phase) Modulated	Absence of Any Modulation	FØ
	Telegraphy (Frequency Shift Keying)	F1
	Telegraphy (Audio Frequency Shift Keying)	F2
	Telephony	F3
	Facsimile	F4
	Television	F5

FOOTNOTE: The use of narrow-band frequency or phase modulation is subject to the condition that the bandwidth of the modulated carrier shall not exceed that of any amplitude-modulated carrier of the same audio characteristics.

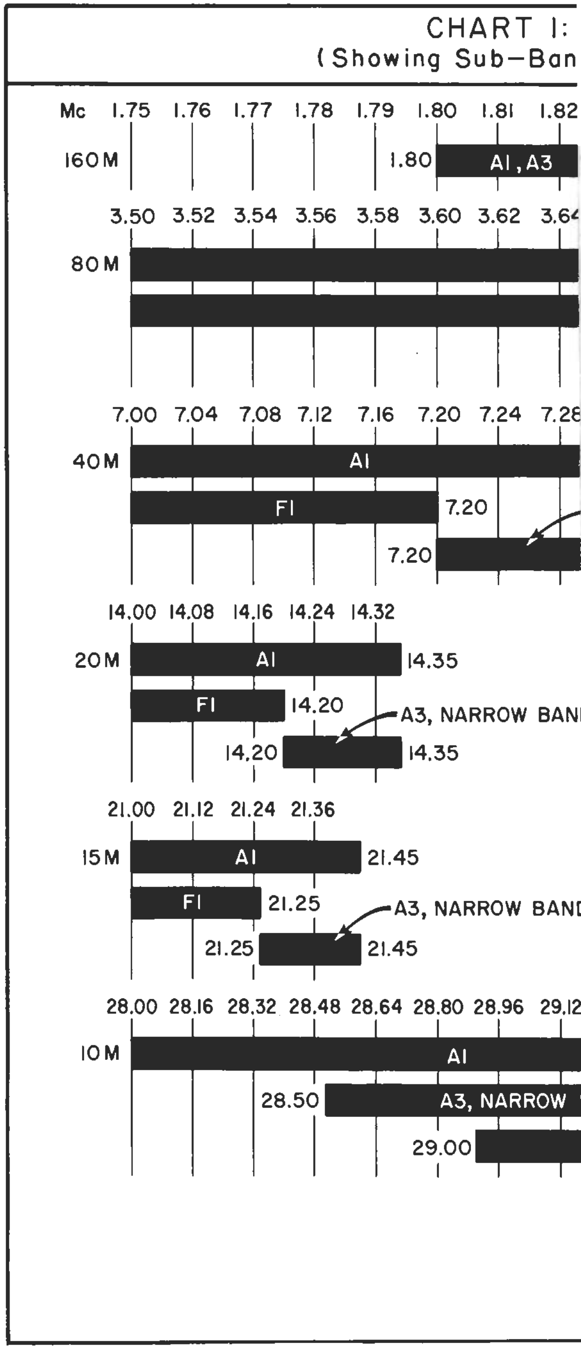
FOOTNOTES TO CHARTS 1 AND 2:

(Chart 1)—Restrictions regarding the 160-meter band vary. Consult FCC Rules and Regulations, Part 12, or the nearest FCC district office for regulations governing your particular area.

(Charts 1 and 2)—Novice-Class licensees may use A1 emission between 3.70 and 3.75 Mc; 7.15 and 7.20 Mc; and 21.10 and 21.25 Mc. Novice operators also may use the same types of emissions authorized to others between 145 and 147 Mc.

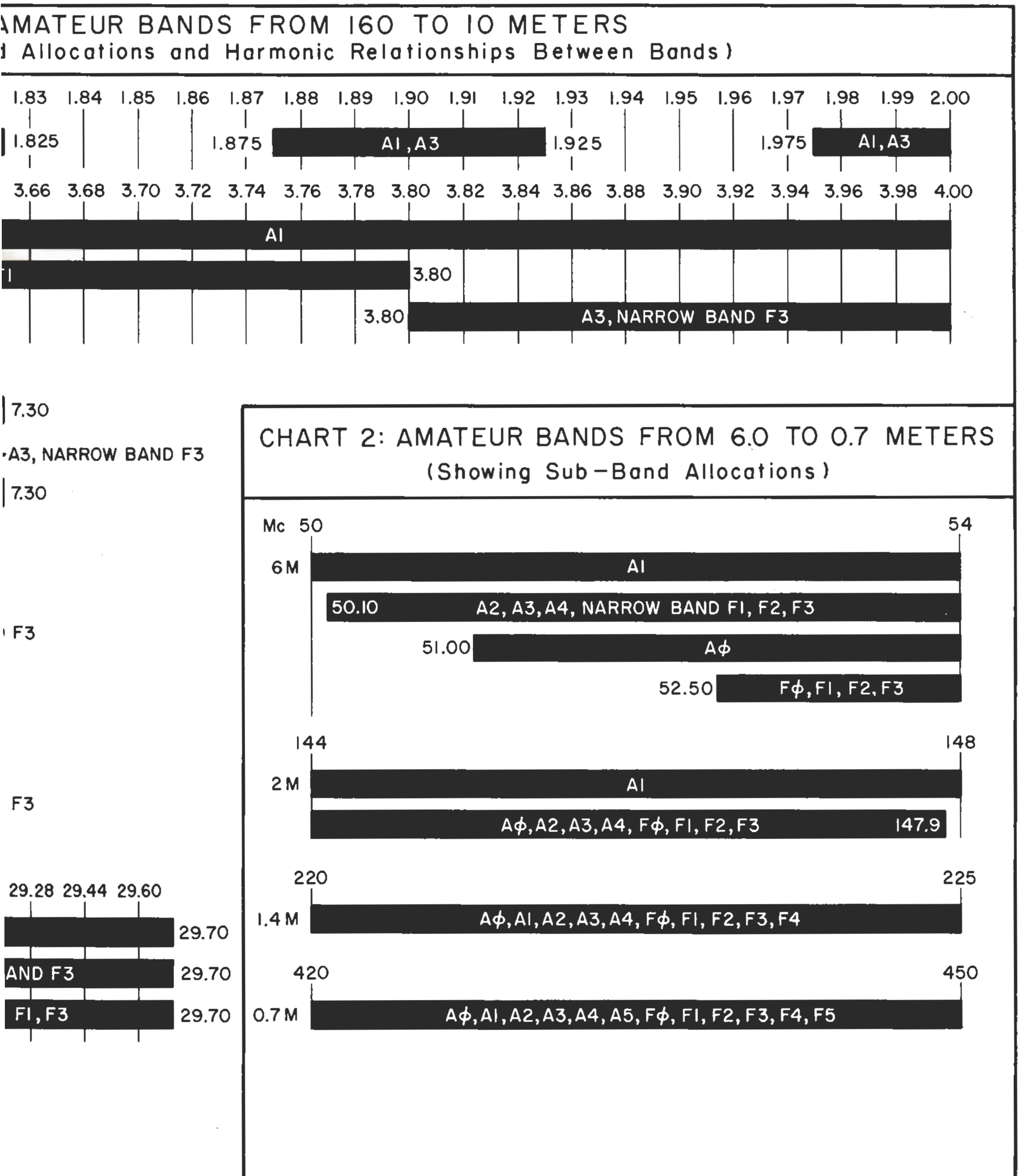
The charts have been compiled from FCC Rules and Regulations, Part 12, as of August 1, 1963. The information is subject to change.

(Chart 2)—Technician-Class licensees may use all emissions authorized between 50 and 54 Mc; 145 and 147 Mc; and all amateur frequencies and emissions authorized above 220 Mc.



emission be used on the frequencies shown in Chart 1. All other "Frequency (or Phase) Modulated" assignments in Chart 1 are specifically narrow-band (6 kilocycles maximum).

Charts 1 and 2 apply only to amateur operators in the 50 states. Operation on 220 to 225 Mc in some parts of Texas and New Mexico is restricted between the hours of 0500 and 1800, Monday through Friday of each week, except when authorized in an organized Civil Defense program. If you live in this area, check with the district FCC Engineer-in-Charge at Dallas, Texas.



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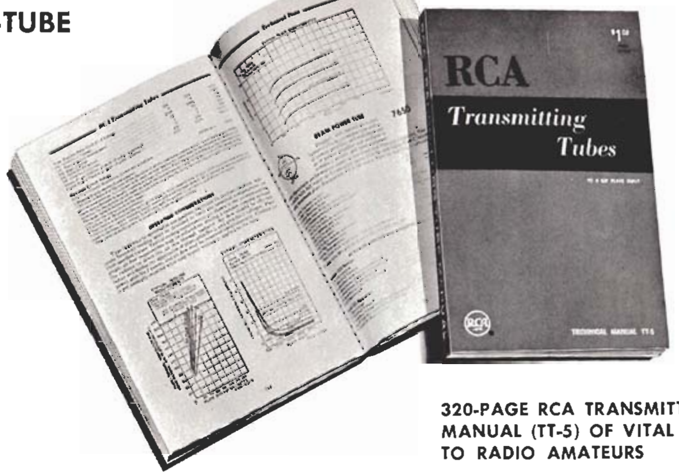

320-PAGE RCA TRANSMITTING TUBE MANUAL (TT-5) OF VITAL INTEREST TO RADIO AMATEURS

RCA's popular TT-5 manual is a treasure-house of information for every radio amateur, engineer, and technician concerned with transmitting tubes.

Thoroughly revised and up-dated to keep pace with advances in power-tube technology, the 320-page manual provides information on the latest RCA transmitting-tube types, including the famed *Cermolox*® family of ceramic-metal tubes.

Coverage of single-sideband information has been considerably increased and includes new single-sideband ratings, discussions of linear power amplifier design, and sample calculations of operating conditions for two-tone modulation.

The popular Circuits Section now contains 23 typical transmitting and industrial circuits. Among these are circuits for a class B linear rf amplifier for single-sideband service; a 120-watt, 50-Mc transmitter; a single-sideband exciter; a 144-to-148-Mc mobile transmitter; and a five-band, 10-to-80-meter transmitter.

The manual's fully illustrated text material covers power-tube fundamentals, construction, applications, operation and adjustment, and installation, as well as rectifier considerations and interpretation of tube data.

Over 180 types of transmitting tubes and related rectifier tubes are included in the Technical Data Section, which gives maximum ratings, characteristics, typical operating values, and curves. Presented in easy-to-understand style, "RCA Transmitting Tubes (TT-5)" represents a valuable reference work that belongs in every ham shack. You can obtain a copy from your RCA tube distributor or by sending $1.00 to Commercial Engineering, RCA Electronic Components and Devices, Harrison, N. J.

From your local RCA distributor, headquarters for RCA receiving and power tubes.

RCA HAM TIPS is published by RCA Electronic Components and Devices, Harrison, N. J. It is available free of charge from RCA distributors.

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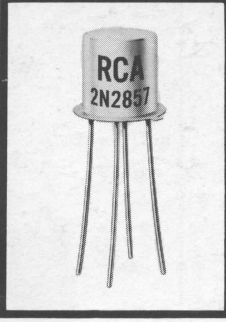


A LOW-NOISE UHF TRANSISTOR AMPLIFIER

By W. A. Pond (WA2JXO), P. E. Kolk, and T. J. Robe*

RCA Electronic Components and Devices

RCA's recently announced 2N2857 npn silicon transistor opens new possibilities in the construction of extremely low-noise UHF transistor receivers and converters for mobile and fixed-station operation.

The 2N2857 utilizes a new miniature electrode structure which provides a very low noise figure (4.5 db max at 450 megacycles), high power dissipation capability (200 milliwatts at 25° C free air temperature and 300 milliwatts at 25° C case temperature), very low leakage at high temperatures, and very small variation in noise figure with temperature (±0.5 db from −40° to +100° C). Under typical operating conditions in 30- or 60-megacycle intermediate-frequency amplifier applications ($V_{CC} = 6$ volts, $I_C = 1$ milliampere, and $R_G =$ 400 ohms), the noise figure of the 2N2857 can be as low as 2db. A 15-db gain and 7.5-db noise figure can be realized in 450-to-30 megacycle converter service.

Designed for UHF, specified for UHF, and 100%-tested for UHF, the RCA-2N2857 can be operated as a common-base oscillator to 1,500 megacycles, and as an amplifier to 1,000 megacycles.

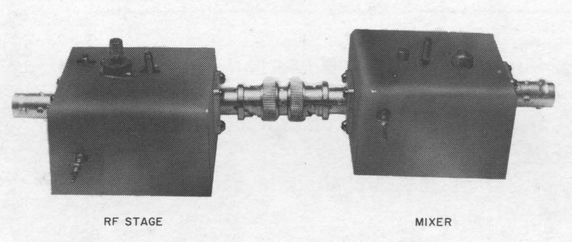


Figure 1: Authors' low-noise UHF transistor amplifier showing two basic chassis (single-stage amplifier, left, and converter, right) as combined unit.

*Commercial Receiving Tube and Semiconductor Division, Somerville, N. J.

If you were among those who attended the 1962 ARRL Convention in Portland, Ore., you may have seen the demonstration of RCA's new 2N2857, a silicon low-noise VHF/UHF transistor used as an amplifier in a 450-megacycle receiver application.

Among the characteristics of the 2N2857 at 450 megacycles are its unneutralized wide-band (approximately 50-megacycle) power gain of 8 db, its neutralized narrow-band (approximately 8-megacycle) power gain of 15 db, and its low noise figure of 4.0 db.

At the show, a single unneutralized common-emitter rf stage was the main unit of demonstration. In addition, a single-stage self-oscillating converter using the 2N2857 was utilized to facilitate detection by a com-

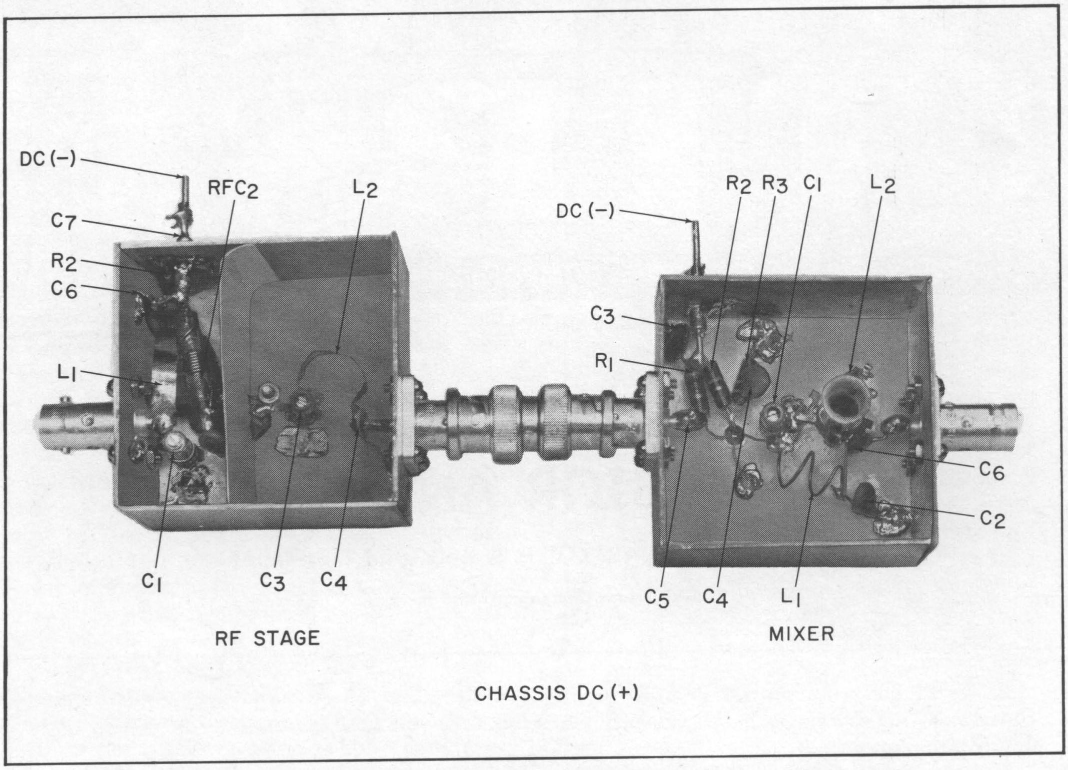
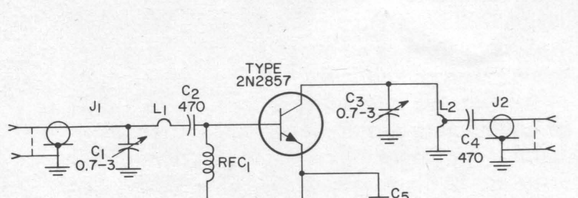


Figure 2: Bottom view of single-stage amplifier chassis, left, and converter chassis, right.

mercial communications receiver at 29 megacycles.

Figure 1 shows the two basic chassis connected. The single-stage amplifier chassis is at the left, and the converter is in the small chassis at the right. A bottom view of these chassis is shown in Figure 2. The tuning inductors in the amplifier stage are lengths of thin copper ribbon curved to approximate a semicircle. These strips, which represent approximately 20 nanohenries of inductance, are relatively high-Q coils. This condition does not mean that the over-all Q of the circuit is high, but only that there are negligible losses in these elements. In fact, in view of the level of reactance chosen (20 nanohenries), and the low parallel input and output resistance of the device at 450 megacycles, the loaded Q of the input tuning circuit is extremely low and that of the output circuit moderate. Accordingly, the input tuning should be used primarily for matching the device to the antenna or source impedance. The output tuning of the stage sets the selec-



C_1, C_3—0.7-3 pf ceramic disc (Erie 535C or equiv.)

C_2, C_4, C_5, C_6, C_8—470 pf ceramic disc (Erie ED470 or equiv.)

C_7—1,000 pf feedthrough (Erie 2404-102 or equiv.)

J_1, J_2—Coaxial chassis connector BNC

L_1, L_2—½ turn, ¼-inch-wide by 1½-inch-long copper foil

RFC_1, RFC_2—0.2 μh

R_1, R_2—10,000 ohms, ¼ watt

R_3—6,200 ohms, ¼ watt

Figure 3: Schematic diagram and parts list of unneutralized rf stage.

C_1—0.7-3 pf ceramic disc (Erie 535C or equiv.)
C_2—33 pf ceramic disc (Erie ED33 or equiv.)
C_3—1,000 pf feedthrough (Erie 2404-102 or equiv.)
C_4—1,000 pf ceramic disc (Erie ED1000 or equiv.)
C_5—470 pf ceramic disc (Erie ED470 or equiv.)
C_6—0.01 μf ceramic disc (Erie ED 0.01 or equiv.)
L_1—2 turns, #22 AWG, 1/4 inch by 5/8 inch
L_2—8 turns, #22 AWG, 9/32-inch form, 1/2-inch long, powdered iron slug
R_1—3,000 ohms, 1/2 watt
R_2—12,000 ohms, 1/2 watt
R_3—33,000 ohms, 1/2 watt

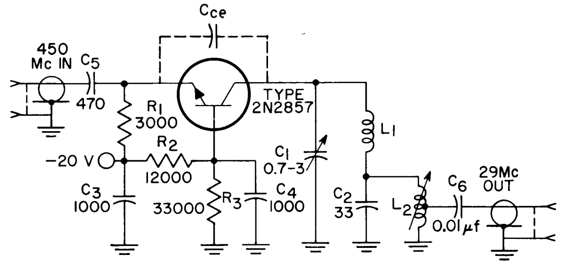


Figure 4: Schematic diagram and parts list of self-oscillating mixer.

C_1, C_2—0.8-8 pf (JFD VC11G or equiv.)
C_3, C_4—0.7-3 pf (Erie 535C or equiv.)
C_5, C_6, C_7, C_8—500 pf ceramic disc (Erie ED500 or equiv.)
J_1, J_2—Coaxial chassis connector BNC
L_1, L_2—1/2 turn, 1/4-inch-wide by 1 1/2-inch-long copper foil
L_3—1/2-turn, #12 AWG Bus wire
RFC_1—0.2 μh phenolic core
R_1—6,800 ohms, 1/4 watt
R_2—2,700 ohms, 1/4 watt
R_3—1,000 ohms, 1/4 watt

Neutralization Procedure:

1. Connect a 450-megacycle signal generator (with Z_{out}=50 ohms) to the input terminals of the amplifier.
2. Connect a 50-ohm rf voltmeter across the output terminals of the amplifier.
3. Apply the supply voltage (−8 volts) and, with the signal generator adjusted for 10-millivolt output, tune C_1, C_2 and C_3 for maximum output.
4. Interchange the connections to the signal generator and the output indicator.
5. With sufficient signal applied to the output terminals of the amplifier, adjust C_4 for a minimum indication at the input.
6. Repeat steps 1, 2, and 3 to determine whether re-tuning is necessary.

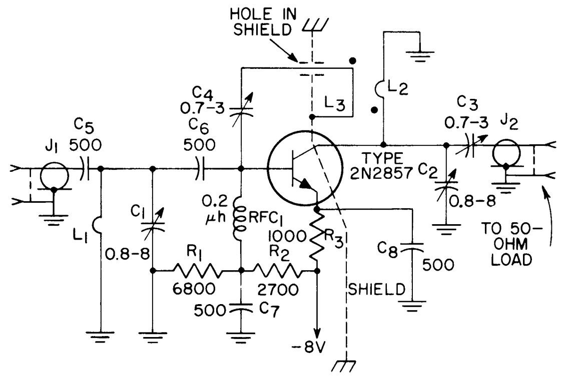


Figure 5: Schematic diagram and parts list of neutralized rf stage.

RCA-2N2857 NPN Silicon Transistor Electrical Specifications

BV_{CBO}	at I_C = 1 μa	30 volts min.
BV_{CEO}	at I_C = 3ma	15 volts min.
BV_{EBO}	at I_E = 10 μa	2.5 volts min.
I_{CBO}	at V_{CB} = 15 volts	0.01 μa max.
h_{FE}	at V_{CE} = 1 volt, I_C = 3 ma	30—150
h_{fe}	at V_{CE} = 6 volts, I_C = 5 ma, f = 100 Mc	10—19
G_{pe} (neut. power gain)	at V_{CE} = 6 volts, I_C = 1.5 ma, f = 450 Mc	12.5—19 db
N.F. (Noise Figure)	at V_{CE} = 6 volts, I_C = 1.5 ma f = 450 Mc	4.5 db max.

tivity by choice of appropriate reactance level, i.e., the reactance of the parallel tuning capacitance or inductance at resonance.

Figure 3 shows the single-stage amplifier, which uses a pi-matching network at the input consisting of the parallel tuning capacitor, the series inductance copper strip, L_1, and the parallel input capacitance of the transistor. The output is simply a tuned tank circuit having the inductance tapped to match the parallel input resistance of the following stage. An alternate method of matching to the next stage is to place a small variable capacitor (0.8—8 picofarads) in series from the collector side of the tank to the next stage. It should be realized that this approach, in effect, places additional capacitance in parallel with the tank inductance and, consequently, may re-

quire a smaller value of inductance, L_2, to resonate at the desired frequency. The parallel input capacitance of the converter is tuned out as part of the over-all tank capacitance of the previous stage.

Figure 4 shows the self-oscillating mixer employing the 2N2857. This circuit oscillates because of the capacitance feedback within the transistor, and is frequency- dependent on the L_1-C_1 tank circuit. C_2 has small reactance compared to L_1 at the radio frequency, but resonates with L_2 at the intermediate frequency.

UHF gain up to 19 db can be obtained from the 2N2857 in the 450-megacycle neutralized circuit shown in Figure 5—if the neutralizing capacitance, C_4, is carefully adjusted. The feedback coupling loop, L_3, is a piece of No. 12 AWG copper wire running parallel to and approximately 1/4 inch from L_2. One end of L_3 is connected to the grounded shield; the other end passes through a hole in the shield to the neutralizing capacitor. It is important that the ground end of L_3 be placed adjacent to the signal end of L_2 to achieve the phase reversal necessary for neutralization.

All of the circuits described have standard mica-filled phenolic transistor sockets designed to accommodate leads arranged in 0.1-inch pin circle. A suitable socket is the Elco 3307 or equivalent. The transistor leads should be cut to about 1/4 inch for best operation. All components connected to the transistor should be mounted as close as possible to the socket to reduce the effects of stray reactances.

! ATTENTION HAMS !

Interested in a handy guide of metric-system terminology? You may find the following table a useful addition to your literature reference file.

Metric System Unit Prefixes

Prefix	Abbreviation	Meaning
pico-	p	10^{-12}
nano-	n	10^{-9}
micro-	μ	10^{-6}
milli-	m	10^{-3}
centi-	c	10^{-2}
deci-	d	10^{-1}
deca-	da	10
hecto-	h	10^{2}
kilo-	k	10^{3}
mega-	M	10^{6}
giga-	G	10^{9}
tera-	T	10^{12}

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